Final Report

Submitted in Partial Fulfillment of the Project
"Updating the Genuine Progress Indicator for the state of Hawai'i"

Funded by the Department of Business, Economic Development and Tourism

February 28, 2022

Submitted by:

Kirsten L.L. Oleson, Ph.D., Associate Professor, University of Hawai'i at Mānoa
Regina Ostergaard-Klem, Ph.D., Associate Professor, Hawai'i Pacific University

Research team:
Kate Crowell
Amanda Shaw, Ph.D.
Samantha Steenhuis
Emelia Von Saltza

UNIVERSITY of HAWAI'I
MĀNOA

HAWAI'I PACIFIC UNIVERSITY

Executive Summary

The Genuine Progress Indicator (GPI) is an indicator of economic welfare representing the costs and benefits of economic activity. GPI has evolved since the 1980s as an alternative method to more accurately and holistically capture social welfare benefits and costs not evident through GDP accounting and is one tool within a broader movement to go “beyond GDP.” A key feature of GPI that discerns it from other holistic indicators is that it monetizes all welfare contributing and reducing impacts of economic activity. Monetization makes all components commensurable and thus facilitates trade-off analysis. Monetization is not uncontroversial, but methods derive from the literature, and estimates rely on publicly available data, ensuring transparency. While GPI, like GDP, is expressed as a single annual number, it can be decomposed into its constituent parts, which consist of indicators related to the economy, as well as environmental and social change.

GPI has been applied at national and subnational/state levels in the US and internationally. Recent work towards developing a newer model, i.e., GPI 2.0, has led to methodological advances, including more comprehensive coverage of non-welfare enhancing expenditures and impacts of economic activity, as well as inclusion of services from various forms of capital. Even so, state studies have diverged methodologically, and current efforts in the GPI community revolve around how to standardize methods and achieve greater policy impact. At the heart of the GPI 2.0 effort is reaching consensus on GPI’s definition, what purpose it serves, and its architecture.

Hawaiʻi GPI 2.0 is the application of the theory, principles, and practices of GPI to the context of the state of Hawaiʻi. The structure of Hawaiʻi GPI 2.0 consists of 13 indicators and 37 subindicators that span economic, social, and ecological components poised to capture both benefits and costs of economic activity within our state. The Hawaiʻi GPI 2.0 is an updated, expanded, and more rigorous version of the GPI as compared to the original efforts from 2014 (Ostergaard-Klem & Oleson, 2014). In addition to documenting important details about the construction and subsequent calculations of Hawaiʻi GPI 2.0, this report directly reflects Hawaiʻi’s efforts to address the critical need for better and more complete measures of social welfare throughout the state. While taking on this challenge within our islands, Hawaiʻi is contributing actively and significantly to the GPI 2.0 movement as well.

Hawaiʻi’s GPI was consistently lower than the state GDP over the study period; the average GPI of $52.62 billion (in 2020 US$) was 66% of the average GDP at $79.3 billion (in 2020 US$) over the period 2000-2020. The discrepancy is easily explained by GPI’s adjustments for non-welfare enhancing expenditures and external costs of economic activity, as well as the inclusion in GDP of additional components. GPI’s growth rate was slightly lower than that of GDP (1.53% vs. 1.55%) averaged across the 20 years. Several distinct periods of discrepancy in rates are not as easy to explain: pre-2006, when GDP growth was higher than GPI growth; 2005 and 2008-2009 when GPI growth was higher than that of GDP; and 2010-2020 when change in both variables roughly tracked one another, albeit with some lag in GPI following GDP. GPI did not decline as quickly or severely as GDP during economic and COVID-19 crises (2009-2010, 2020), although the implications of COVID are still emerging. Services from human capital were the largest contributor to GPI, followed by adjusted personal consumption. Deductions for loss of natural capital were the largest amongst the three cost categories (social costs and pollution being the others).

GPI, though not perfect, represents a substantial advance over GDP in setting our state on a more balanced economic pathway. And Hawaiʻi, through DBEDT, has taken a huge step towards that goal and can continue to show leadership through its support for and eventual implementation of GPI statewide. We propose several next steps, including: further modifying/revising methods within GPI for theoretical consistency; supplementing GPI with more locally appropriate indicators and/or data; building narrative accounts to provide a helpful and more complete context for GPI indicators; supplementing with auxiliary data or other indicators that are not easily monetized; integrating GPI with other sustainability tools such as natural capital accounting; and exploring GPIʻs use in policy analysis. We also see future benefits to be gained by engaging with community and other stakeholders, leading to increased awareness, greater support, and wider policy uptake.

This final report contains the following deliverables: an extensive literature review of Beyond GDP and best practices for GPI; the design for Hawaiʻi GPI 2.0 framework; summary figures explaining the GPI indicator estimates for years 2000-2020; and relevant sensitivity analyses. This report complements an online folder with detailed spreadsheets with all GPI calculations, all training materials delivered to-date, and an operations manual to guide updates to the GPI in future years.

Table of Contents

Executive Summary **1**

Beyond GDP literature review **7**
The Beyond GDP Movement 7
Limitations of GDP as a Measure of Society’s Well-being 11
Non-market activity 12
Distribution effects 12
Costs of economic growth 12
Natural capital depletion 13
Subjective well-being 13
Service and sharing economy 14
Sustainability 14
Why are we still using GDP despite all its flaws? 14
Classification of Beyond GDP Indicators 16
What Makes a Good Indicator 17
Typologies of Beyond GDP Indicators 18
Indexes 18
Dashboards 19
Adjusted economic measures 20
Sustainability indicators 21
Subjective well-being (SWB) indicators 22
Examples of Beyond GDP Indicators 23
Table 1. Examples of Beyond GDP indicators 25
Beyond GDP in Hawaiʻi 27
Hawaiʻi Green Growth Aloha + Challenge Dashboard 27
UH Center of the Family/DBEDT Quality of Life in Hawaiʻi 27
Aloha United Way ALICE Reports 28
Vibrant HI 28
Hawaiʻi Data Collaborative 28
Hawaiʻi Sustainability 2050 28
ʻĀina Aloha Economic Futures 29
Moving Beyond “Beyond GDP” 29

Genuine Progress Indicator (GPI) Literature Review **33**
History of GPI 33
Figure 1. GPI timeline and indicators 34
Theoretical foundations 35
Strengths of GPI 36
Critiques of GPI 37
GPI in the U.S. 39

State studies 39
Policy use of GPI in the states 41
GPI 2.0 42
The need for GPI 2.0 42
Figure 2. Various ways authors define GPI (Van der Slycken & Bleys, 2020) 43
State of the art 43
Table 2. Components of narrow versus broad approach (Van der Slycken & Bleys, 2020) 46
Moving forward with GPI 2.0 47

Hawai‘i’s GPI 2.0 Framework 48
What Hawai‘i’s GPI 2.0 looks like 48
Figure 3. Components of GPI 48
Figure 4. Indicators within GPI 50
Table 3. Indicator and subindicator descriptions 51
Building the GPI structure: Two approaches, many options 55
Examined which GPI approach meets the goals set out by DBEDT. 55
Surveyed the current landscape of sustainability indicators in Hawai‘i. 55
Reevaluated previous GPI work in Hawai‘i 56
Figure 5. OEQC State of the Environment reports featuring GPI 56
Evaluated the pros and cons of a “narrow” versus a “broad” approach to GPI. 56
Table 4. Factors we used to compare and evaluate a narrow versus a broad approach. 57
Determined which indicators should be used 57
Table 5. Method confidence (M) and data availability (D) for each indicator in both Talberth & Weisdorf (2017) and Van der Slycken & Bleys (2020) approaches. 58
Populating the structure: Worksheets, indicator formulae, and data 59

Hawai‘i’s GPI Indicator Estimates (2000 - 2020) 61
Table 6. Average performance of key indicators (2000-2020) 61
Figure 6. Total GPI vs. GDP (total and change) 62
Figure 7. GPI, per capita GPI, GDP, per capita GDP (total and change) 63
Figure 8. GPI indicators as a stacked bar graph 64
Figure 9. GPI indicators as line graph 65
Figure 10. Adjusted PCE 66
Figure 11. Adjusted PCE, without PCE 67
Figure 12. Defensive and regrettable expenditures subindicators 68
Figure 13. Household investment subindicators 69
Figure 14. Services from human capital subindicators 70
Figure 15. Pollution subindicators 71
Figure 16. Services from built capital subindicators 72
Figure 17. Social cost subindicators 73
Figure 18. Depletion of natural capital subindicators 74

Figure 19. Services from protected areas subindicators 75
Figure 20. Services from protected areas, without palustrine wetlands and forests 76
Figure 21. Utility and disutility by market vs. non-market components 77
Figure 22. Utility and disutility by category 78

Sensitivity Analysis **79**
Defensive and regrettable expenditures (DEFR) 79
Income inequality 80
Figure 23. Diminishing marginal utility of income ratio for both threshold methods (med = median; ST = sufficiency threshold) 81
Ecosystem services 81

Continuing to Update Hawai‘i’s GPI **82**
Figure 24. Level of effort required for next steps in developing Hawai‘i’s GPI 83

Bibliography **85**

Appendix A Tables **1**
Table A-1. Comparison of indicators & methods across Ostergaard-Klem & Oleson (2014), Talberth & Weisdorf (2017) and Van der Slycken & Bleys (2020) with working comments for Hawai‘i 1
Table A-2. Proposed modifications and/or additions to several key social indicators 18

Appendix B Indicator data availability **1**

Population **1**

CPI-U **2**

Personal Consumption Expenditure (+PCE) **2**

Defensive & Regrettable Expenditures (-DEFR) **4**
Food & Alcohol 4
Tobacco 5
Insurance & Financial Services 5
Food Waste 6
Household Pollution Abatement 7
Air Pollution Abatement 8
Waste Water & Solid Waste Pollution Abatement 10
Medical & Legal Services 10
Energy Waste 11
Lotteries 11

Household Investments (-HI) **12**
Household Repairs/Maintenance & Home Improvement 12

Consumer Durable Expenditures (-CDE)	**13**
Cost of Income Inequality (-INQ)	**14**
Public & Non-Profit Provision of Goods & Services (+PP)	**15**
Services from Social/Human Capital (+KH)	**17**
College Graduates	17
Manufacturing Jobs	18
Green Jobs (not included in GPI calculation due to data gaps)	18
Unpaid Work	19
Leisure	20
Internet	21
Services from Consumer Durables (+CDS)	**22**
Services Built Capital (+KB)	**23**
Transportation	23
Water Infrastructure	24
Household Improvements	25
Services Protected Areas (+KN)	**26**
Local Pollution Costs (-POL)	**28**
Air	28
Water	29
Noise	29
Solid Waste	30
Greenhouse Gasses	31
Depletion of Natural Capital (-DNK)	**34**
Non-Renewable Energy	34
Groundwater (not included in the GPI calculation due to data gaps)	36
Soil Erosion	37
Land Conversion	37
Social Costs (-SC)	**40**
Houselessness	40
Underemployment	40
Crime	41
Vehicle Crashes	43
Commuting	44

1. Beyond GDP literature review

The **Beyond GDP** initiative is about developing indicators that are as clear and appealing as Gross Domestic Product (GDP), but more inclusive of environmental and social aspects of progress. Economic indicators such as **GDP** were never designed to be comprehensive measures of prosperity and well-being (*Beyond GDP: Measuring Progress, True Wealth, and the Well-Being of Nations (European Commission)*, n.d.). Nevertheless, GDP continues to exert tremendous influence over economic policy and decision making. Below we provide an overview of the Beyond GDP movement and a review of the accompanying literature. What becomes clear is the general agreement on the limitations of GDP, the need to go beyond GDP, and ever more pressing goals to incorporate alternative indicators and tools into the policy process.

1.1. The Beyond GDP Movement

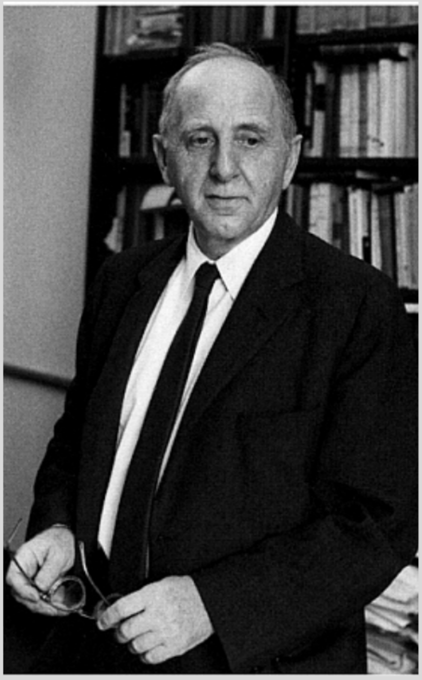
"... it measures everything in short except that which makes life worthwhile"
-Robert F. Kennedy (1968)

Since the 1960s, the institutionalization of GDP as a measure of social welfare and progress has received much criticism from respected economists to politicians alike. van den Bergh (2009) cites at least 20 publications in his study, from Hicks in the 1940s to Krueger, Schkade, Schwarz, and Stone in 2004. These works have shown that the Beyond GDP movement has garnered support not just from prominent economists, but also from Nobel laureates, who have acknowledged the limitations of GDP as a proxy for social welfare. In his famous speech in 1968, Robert F. Kennedy recognized that GDP fails to measure "that which is important to us." Measures of economic well being must go beyond GDP to incorporate environmental and social aspects to create a fuller picture of the health of a nation's economy.

The idea of GDP came about in 1934 when in the United States, the National Bureau of Economic Research was tasked with providing estimates of national income in response to the economic failures of the Great Depression. Simon Kuznets presented the report using GDP as a tool to measure economic activity from the production of goods and services (Costanza et al., 2009). The work of Kuznets in the U.S. and Richard Stone and James Meade in the UK advanced GDP as an indicator of economic and political concepts, especially during the Great Depression and World War II. Government spending was seen as a way to boost the economy since it would increase GDP (Marcuss & Kane, 2007; van den Bergh, 2009). Early on, Kuznets cautioned that welfare of a nation cannot be determined by only looking at GDP (Bleys & Whitby, 2015). Kuznets' GDP calculation excluded nonmonetary transactions such as family care, charity, secondhand use, and odd and illegal jobs. The fact that fiscal spending increases economic growth but does not necessarily equate to benefiting individual welfare would become the premise for the Beyond GDP movement (Costanza et al., 2009).

By 1944, GDP became the primary tool to measure economic progress after gaining support at the Bretton Woods Conference, whose goal was to avoid another world war through increasing global economic prosperity, political stability, and fostering peace (Clemens & Hamilton, 1999; Costanza, Hart, et al., 2014a). The official United States National Income Accounts used GDP to compare growth, as did subsequent quality of life studies in different countries (Costanza, Hart, et al., 2014b). By the 1950's, GDP accounting methods had become the norm that was used by the United Nations and the World Bank and International Monetary Fund.

WHO WAS SIMON KUZNETS?



Kuznets, a Russian-American economist, was one of the leading figures behind the creation of GDP for national income accounting. In 1971 he won the Nobel Memorial Prize in Economics because of his research on economic growth. His calculation for GDP is recognized as growth, and now more commonly referenced as wellbeing, as consumption + investment + government spending + (exports − imports). This equation ignores any kind of economic activity that does not produce new wealth such as used goods or the spread of knowledge through open access sites. In his report to the U.S. Congress in 1934 he warned that, "the welfare of a nation can scarcely be inferred from a measure of national income. If the GDP is up, why is America down? Distinctions must be kept in mind between quantity and quality of growth, between costs and returns, and between the short and long run. Goals for more growth should specify more growth of what and for what" (Halton & Boyle, 2021; OECD, 2007).

John Maynard Keynes famously argued that government spending was necessary to stimulate the economy (Halton & Boyle, 2021; OECD, 2007). During the war, GDP measurements were concerned primarily with supply. In the post-war years, the focus switched from production of to demand for goods as estimates of welfare. The Organization for European Economic Cooperation (OEEC) created GDP accounting templates for its member states, making comparison of growth rates across countries possible (i.e., the International Comparison Project of 1968). GDP growth became a goal, prescriptive instead of descriptive, that consequently became a reason for criticism (Coyle, 2014d; The Economist, 2016).

Criticism of GDP focused on its shortcomings catalyzed decades of research on potential alternatives to GDP. With the onset of the Vietnam War, the United States' economy saw high inflation rates and unemployment regardless of government spending, which challenged Keynesian views on GDP. The “expand or die” mindset from the war was countered with the idea that GDP growth could be uneconomic as GDP only measures monetary transactions of produced goods and services and does not reference the entire economic system (Daly, 1987). Instead, an idea of sustainable income arose, in which consumption is viewed in partnership with human-made and natural capital to determine welfare, as well as subjective measures of happiness and quality of life (Bleys, 2012; Samuelson, 1961).

In the 1970s, social scientists questioned the use of GDP as an exclusive indicator for welfare and created subjective surveys for quality of life and well-being such as Hadley Cantril’s Self-anchoring striving scale and Norman Bradburn’s Affect-balance scale (Giovannini & Rondinella, 2018). The Club of Rome formed in 1972, and created a report, Limits to Growth, which advocated for a new approach to economics (among other things). While the report gained traction in some circles, its messages were mostly disregarded in favor of political interests (Kanninen, 2012). Nevertheless, it laid the foundation for the emergence of ecological economics, with a basic premise that increasing production as a reason to increase economic growth encourages natural resource depletion. Forced GDP growth stretches the limits of planetary boundaries and wrongfully assumes that the economy is an independent system rather than a subsystem of the environment (Daly & Farley, 2011). A constant growth mindset was also criticized for creating one time welfare effects for consumers. This “hedonic treadmill” of consumption equating to happiness and growth is not a true measurement of societal well being (Brickman and Campbell (1971) as cited in van den Bergh (2009). Similarly in 1974, an article on the now famous Easterlin Paradox was published which argued that economic growth only increased happiness up to a certain level. People living in rich countries were in fact happier compared to people living in poor countries; however, within a single rich country, further economic growth (measured as GNP) did not seem to cause increased happiness. Instead, Easterlin concluded that “higher income was not systematically accompanied by greater happiness” (Easterlin, 1974; Kullenberg & Nelhans, 2017).

Further social research from the 1980s showed that income inequality had increased internationally, with the rate of growth being unequal as well. While GDP had technically increased, global inequality had worsened with the top 1% richest individuals in the world experiencing twice as much growth as the bottom 50% of individuals (Shrotryia & Singh, 2020). While it is supposed that increases in GDP increases lead to increases in individual welfare, that is not always the case. The Human Development Index (HDI) was developed in 1990 to measure capabilities rather than income. It emphasizes that people and their capabilities should be the ultimate criteria for assessing development of a country, not only economic growth (UNDP, 2021). Nobel laureate and developer of HDI, Amartya Sen, noted that poverty and famine cannot be solved by increasing income levels, because it is the fault of the government for not caring for the needs of their citizens. No matter the annual GDP growth rate or overall GDP levels, democracies do not suffer rampant famines (Coyle, 2014c).

The Index of Sustainable Economic Welfare (ISEW), now known as the Genuine Progress Indicator (GPI), emerged in 1989, taking into account GDP, unpaid household labor, social costs, environmental damage and income distribution. Kubiszewski et. al. (2013) explain that

GPI indicates when welfare is going down because it is made up of a cost and benefit analysis in relation to the environment, which GDP excludes (Kubiszewski et al., 2013).

Despite increasing evidence against GDP's role as a measure of well-being, a surge in technology from the 1980-1990s rapidly increased GDP and allowed for increased innovation and investments to take place which was seen as progress (Coyle, 2014b). The more advanced technology businesses could acquire, the more they could produce, and the more they could earn. The economy was booming and policy makers world wide saw GDP as a successful mechanism. In contrast, however, 1992 marked a significant point in the Beyond GDP movement, because the Rio Earth Summit concluded that sustainable development should couple economic growth with ecological responsibility (UN, 1992).

Since then, the Beyond GDP movement has gained even more traction, coinciding with the launch of the Millenium Development Goals (MDGs) by the UN in 2000 and an increase in global commitment to sustainability. In 2007 the European Commission, European Parliament, Club of Rome, OECD, and World Wildlife Fund hosted a conference on Beyond GDP to discuss the best tools for measuring progress (Costanza et al., 2009; European Commission, 2007). Shortly thereafter, the Commission on the Measurement of Economic Performance and Social Progress was created. In 2009, on the heels of the 2008 global financial crash, the commission delivered the Stiglitz-Sen-Fitoussi report highlighting classical GDP issues, quality of life, and sustainable development and environment (Bleys, 2012).

The 2008 recession spurred movement away from GDP measurements in some cases, but in others, policy makers clung to traditional economic policy, illustrated for example by the American Recovery and Reinvestment Act pumping $787 billion into the economy (Boyle, 2020). Nevertheless, doubts about the strength of GDP continued, especially related to the BRICS (Brazil, Russia, India, China, South Africa) nations for example. The emerging economics within the BRICS nations could potentially overtake developed countries based on size of GDP. However high GDP does not equate to wealth or well being of a society (Coyle, 2014a). For example, despite experiencing a near double GDP increase every eight years, China is faced with an aging population with minimal welfare options and political problems.

The Stiglitz report from 2009 was updated in 2018 to reflect dichotomy and show that the Beyond GDP movement is not "anti-growth" per se and instead supports the idea that social well being and economic prosperity are a multifaceted issue that policy should aim to pursue (Stiglitz et al., 2018). This was reflected in the 2011 launch of the OECD Better Life Index (BLI) which aimed to combine the indicators of housing, income, jobs, community, education, environment, governance, health, life satisfaction, safety, work-life balance to measure well-being in OECD countries (OECD, 2021). In 2015, the UN rolled out their next iteration of sustainable development indicators with the launch of the 17 Sustainable Development Goals (SDGs) to be achieved by 2030.

More recently, COVID-19 and the global pandemic has exposed weaknesses in social systems such as health, economic, racial disparities and injustice. Emerging and developing economies are suffering from a limited healthcare system that is now exacerbating slow economic growth in terms of GDP. The shock from COVID-19 has seen a sharp global recession that calls for a new normal to take into consideration the needs of all individuals (World Bank, 2020). While stimulus packages are centered around boosting GDP such as by loosening lending restrictions for mortgages, it will increase debt and raise housing prices to benefit the already wealthy and not provide equal relief to all income levels (Roberts, 2020).

The World Bank Global Economic Prospects report for 2021 explained that recovery must integrate what is valuable to society through investing in human capital, reducing regulatory burdens, addressing market distortions, and improving access to social services. Investments in environmentally friendly initiatives can support higher growth levels while mitigating climate change (Strand & Toman, 2010; World Bank, 2020). Combining environmental goals with economic objectives can increase resilience of emerging and developing economies and is not something that would be recognized if GDP continues to be the medium to access well-being (Agrawala et al., 2020; IEA, 2020; World Bank, 2020).

In March 2021, the UN Statistical Commission made a significant contribution to the beyond GDP movement through the release of the System of Environmental Economic Accounting –Ecosystem Accounting (SEEA - EA) framework. The EA piece complements previous green accounting efforts by UN SEEA and serves as a "framework for organizing data about habitats and landscapes, measuring ecosystem services, tracking changes in ecosystem assets, and linking this information to economic and other human activity" (UN, 2021). The SEEA itself was introduced in 2012 as the first international standard consistent with the System of National Accounts (SNA), bringing together economic and environmental information "in an internationally agreed set of standard concepts, definitions, classifications, accounting rules and tables to produce internationally comparable statistics" (UN, 2021). This updated statistical framework for ecosystem accounting moves beyond GDP and takes better account of biodiversity and ecosystems and the ecosystem services they provide in national economic planning and is a major development in changing the way to think about prosperity and well-being (UN, 2021).

The inception of GDP as a financial indicator was meant to enable economists to see warning signs that were previously missed prior to the Great Depression. Yet experts in the Beyond GDP field point out that GDP calculations are overvalued. Take, for example, the external costs that are suffered through depletion of natural capital and overuse of resources that are valued at a greater monetary price than that which is left alone in nature (van den Bergh, 2009). Overall, GDP has evolved into a measurement of economic quality and welfare rather than just explaining quantity (Costanza et al., 2009). More details on the limitations of GDP as a measure of progress are discussed next.

1.2. Limitations of GDP as a Measure of Society's Well-being

GDP is a measure of the size of the economy (quantity) rather than one of economic welfare (quality). *(Bleys & Whitby, 2015; Costanza et al., 2009)*

The limitations of GDP as a broader measure of well-being are widely noted within the literature and include both specific gaps and overall structural flaws. The areas that GDP overlooks can be generally grouped according to: non-market activities, distribution effects, and costs of economic growth and natural capital depletion. Structurally, GDP is not currently equipped to take advantage of new empirical findings within the field of subjective well being, to consider new types of economic prosperity, or to broaden the boundaries of time and scale particularly as related to sustainability.

Non-market activity

Designed exclusively to capture market activity as the assumed marker of a healthy economy, GDP does not account for any type of unpaid service taking place outside of the formal market itself. Informal activities such as child care, housework, elder care, subsistence agriculture, or volunteerism add immense value to our lives and build social capital that cannot be captured by GDP (Kubiszewski et al., 2013; van den Bergh, 2009). Fioramonti (2017) points to a study from the US Bureau of Economic Analysis estimating the average value of household production in the US at over 30 percent of economic output each year from 1965 to 2010, from a high of 39% in 1965 to just below 26% in 2010. Estimates from the IMF for developing countries in the early 2000's were even higher, upwards of 44% (Fioramonti, 2017).

Distribution effects

GDP per capita is routinely used to compare the standard of living across different economies of the world. In fact, the World Bank relies on per capita GDP to not only classify the world's economies into four income groups — high, upper-middle, lower-middle, and low – but determine its operational lending policies as well (World Bank, n.d.). While GDP per capita positively correlates with important indicators of well-being such as life expectancy at birth, infant mortality, adult literacy rate, van den Bergh (2009) cautions that correlation does not guarantee causation. As it only focuses on average income, GDP per capita indicates nothing about the distribution of income within the society and masks patterns of inequity that can arise particularly in the presence of small outlying concentrations of affluence. As such, van den Bergh (2009) warns that unequal distribution implies unequal opportunities for personal development (the capabilities approach), recalling (1990) primary objection to GDP use as a social welfare measure.

GDP does not distinguish between "the haves and have-nots" (Costanza et al., 2009, p. 10) or the types of goods that they buy. While busy counting the sales of final goods and services within an economy that year, GDP does not stop to distinguish whether those goods are purchased by the poor to meet basic needs or by the rich as luxuries or status goods, thus omitting consideration of relative income (van den Bergh, 2009). Furthermore, an increase in GDP per capita is not adequate compensation if and when failing to meet basic needs (van den Bergh, 2009, p. 120).

Costs of economic growth

As GDP tracks the transactions of final goods and services within a market, an increase in GDP by design implies an accompanying increase in production of those goods. Yet also by design, GDP does not register external environmental costs, like pollution, that result not just from the production of a good, but also over the good's entire life cycle. In some cases, GDP can actually increase as the expenditures to cleanup environmental damage are counted positively as market transactions, leading to cost-benefit conflation. Kubiszewski et al. (2013) give the example of remediation from an oil spill; Costanza et al. (2009) point to Hurricane Sandy's boost to GDP from rebuilding. Similarly, defensive expenditures to protect ourselves from environmental health risks (e.g. air filtration systems) can show up as positive additions to GDP. Besides environmental impacts, other negative externalities placed on society, whether direct or indirect results of economic growth, may include loss of amenities such as leisure time.

Natural capital depletion

Just as economic growth results in external costs from polluting our natural sinks (air, water, etc.), it leads to the depletion and depreciation of our stocks of natural capital (the raw materials and services provided by nature). Van den Bergh (2009) points out that depreciation of renewable resources (e.g., fish stocks, forests, biodiversity) and depletion of non-renewable resources (e.g. fossil fuels and metal ores) are missing from GDP calculations. Costanza et al. (2009, p. 9) suggest that reliance on GDP actually encourages natural resource depletion "because clear-cutting a forest for lumber is valued more in GDP terms than the ecosystem services that forest provides if left uncut." The resulting GDP calculation then "suggests that we are richer than we really are" (van den Bergh, 2009, p. 120).

Subjective well-being

GDP is designed as a measure of economic performance, but as Kubiszewski et al. (2018) among others point out, it is generally considered to be the primary contributor to well-being within that economy. Ironically, GDP includes no factors, either objective or subjective, relevant to well-being in its calculations and is even more out of date given recent advancements in the field of subjective well being. Bergh (2009) asserts that a growing field of empirical subjective well-being studies has generated many insights about the determinants of happiness so that absolute individual income is not a suitable proxy of individual welfare. Other factors like relative income and various income-independent factors also influence individual welfare or happiness, making it even more apparent that the aggregation of individual absolute incomes in a GDP does not provide a robust indicator of social welfare at the national level (van den Bergh, 2009). Regardless, subjective indicators and mixed (both subjective and objective) assessments (e.g. work by the New Economics Foundation) are receiving moderate and increasing attention by policy makers (Muraca & Schmelzer, 2017).

Additional important insights can be gained from advancements in the subjective well-being field but remain at length for GDP calculations. For example, GDP fails to consider the "threshold effect" that occurs once a certain income level is reached and GDP per capita begins to negatively correlate (van den Bergh, 2009, p. 120). Kubiszewski et al. (2018) refer to multiple studies observing that further improvements in GDP beyond a certain threshold do not lead to an increase in the overall societal well-being. Yet another phenomenon identified through subjective well-being studies but missing from GDP is that individuals adapt to changed circumstances (like a rise in income) such that their well-being rises only temporarily and ultimately returns to its baseline level after a brief time (Hoekstra, 2019; van den Bergh, 2009). Research has led to techniques using life satisfaction to measure benefits that can then be incorporated into cost-benefit analysis (O'Donnell & Oswald, 2015).

Service and sharing economy

In addition to the long standing criticisms of GDP, Fioramonti et al. (2019) raise new concerns about GDP's lack of relevance, giving wrong signals to policy makers. Recent trends towards economic models embracing service, sharing, and circularity are leading to new forms of prosperity that are missed if only GDP is used. Examples of such environmental, social, and economic improvements include: innovative product design for increased durability and decreased demand on natural resources; closed loop manufacturing; "prosumerism" and low impact lifestyles; collaborative consumption models and bartering (Fioramonti et al., 2019).

Sustainability

The calculation of GDP tracks economic activity during a defined time period (typically a year, but always in the near term) and within the regional boundaries of that economy. The adherence to such constrained time and regional scales automatically disqualifies GDP as an indicator of sustainability. To sufficiently address principles of sustainability, the short term growth mindset needs to be replaced with longer time periods that span across generations, and broader regional boundaries that account for transboundary use of both sources and sinks. As such, O'Neill et al. (2018) call for a move beyond GDP's 'growth at all cost' to where humans take decisive action to prosper within the planetary boundaries. One leading framework complements the concept of planetary boundaries (following (Rockström, n.d.) with social boundaries to form "a doughnut-shaped space" in which the inner circle represents resource use sufficient to meet people's basic needs but not to exceed the outside circle representing the planetary boundaries (O'Neill et al., 2018; Raworth, 2013). Other basic tenets of sustainability are clearly missing from GDP calculations. For example, Fioramonti et al. (2019) contrasts GDP with the 17 UN Sustainable Development Goals, in which the latter recognizes "the complex interconnectedness among social, economic, and environmental elements on top of an interdependency of human/ecosystems" (Fioramonti et al., 2019, p. 208).

1.3. Why are we still using GDP despite all its flaws?

We face what van den Bergh (2009) called a GDP paradox, i.e., "despite all theoretically and empirically motivated criticism of GDP as a social welfare and progress indicator, its role in economics, public policy, politics and society continues to be influential" (van den Bergh, 2009, p. 127). Moreover, regardless of fifty-plus years of the Beyond GDP movement and hundreds of metrics developed, "GDP is still the most influential indicator in society and none of the alternatives come close to its influence" (Hoekstra, 2019, p. 8). GDP is "still carrying the day" (Bjørnholt & McKay, 2014, p. 101; Fioramonti, 2017). Several reasons arise in the literature for why the Beyond GDP movement has not made more progress.

Those who benefit most from strong GDP growth will also have a strong interest in maintaining the status quo. Costanza et al. (2009) include industries and businesses who gain financially by increasing economic activity. Fioramonti (2017) asserts that GDP boosts "not only the economic relevance, but also the social acceptability of polluting industries and large corporations in general" (Fioramonti, 2017, p. 91). Furthermore, as GDP captures the value of final goods and service, countries in which these final goods are produced are rewarded more (Borowy & Schmelzer, 2017; Fioramonti, 2017). Some ambivalence to change may be attributed to policy makers as well (Borowy & Schmelzer, 2017; Fioramonti, 2017), especially given the potential risk that new indicators might reflect badly on current policies and those in charge of making those policies (Costanza et al., 2009). Costanza et al. (2009) also includes the institutions charged with collecting, managing, and reporting on the current indicators.

Other supporters of the status quo may believe that even with its shortcomings, GDP still provides useful information, e.g., as a measure of productivity, and should not be replaced until an acceptable alternative is established (van den Bergh, 2010). Likewise, regular measures and reporting of GDP growth can lend confidence and perceived stability to the market (van den Bergh, 2010).

The UN's System of National Accounts (SNA), also referred to as the "blue book" of national income accounting, represents "a globally harmonized accounting framework" and "dictionary of terminology" that is practiced by all countries that calculate GDP. Not only does the SNA aid macroeconomists from all over the world in developing models and projections, but the standardized methods also make it possible for GDP (per capita) calculations to be compared across countries (Hoekstra, 2020; van den Bergh, 2010). Under that framework provided by the UN SNA, countries have spent decades investing in the relevant infrastructure required to gather and report GDP on a regular basis (Costanza et al., 2009). The path dependencies that have consequently formed "make statistical reform so hard to achieve and very slow at best" (Borowy & Schmelzer, 2017, p. 102; Fioramonti, 2017). Although updates to the UN SNA to integrate guidance on economic and environmental accounting, Fioramonti (2017) comments that implementation of those changes is not evident.

Costanza et al. (2009) believe that the existing paradigm of economic growth or "the belief that growing GDP will solve all economic problems" is the main force supporting GDP's continued use and the biggest obstacle to change (Costanza et al., 2009, p. 27). Moreover, Fioramonti (2017) describes how the statistic "has become an all-powerful presence in our economic and political debate, as well as in our collective social psyche" (Borowy & Schmelzer, 2017, p. 91; Fioramonti, 2017). According to Fioramonti et al., (2019) GDP is an economic model that "has acquired a profound institutional power" and is driven by "industrial production, large corporations, and mass consumption" (Fioramonti et al., 2019, p. 208). Hayden (2021) contends that merely choosing another indicator will not curtail the need for either businesses or governments to maintain the growth mindset.

1.4. Classification of Beyond GDP Indicators

Since the early 2000s, the Beyond GDP movement has led to “an explosion of indicators” (Bleys, 2012, p. 356) and the various indicators attempting to measure well-being number in the dozens (Kubiszewski et al., 2013). Choosing among these indicators is central to the Beyond GDP movement because “what we measure affects what we do. If we measure the wrong thing, we will do the wrong thing. If we don’t measure something, it becomes neglected, as if the problem didn’t exist” (Stiglitz et al., 2018, p. 1). Yet while some are more prominent than others, no ideal alternative indicator exists (Kubiszewski et al., 2013, p. 361). Moreover, no consensus exists on how to best categorize the breadth of Beyond GDP indicators, even though classification schemes would help policy-makers to review, debate, and choose “a proper set” of alternative indicators and identify relevant data gaps (Bleys, 2012, p. 356; Wu & Wu, 2012, p. 72). The objective of this section is to provide an overview of the most prominent typologies of Beyond GDP indicators within the literature.

Although many authors have sampled and reviewed alternative indicators and proposed different classification schemes, not one clear, definitive, and generally accepted framework exists. The multiple frameworks vary according to the underlying theory, discipline, methodology, and scale. Classifications in the early 2000’s typically aligned with the disciplines of economics, sociology, and psychology, building upon Diener and Suh’s (1997) explanation of how “economists start from the idea of preference satisfaction through consumption to build income-related measures, sociologists mostly start from a set of normative ideals to quantify well-being, while psychologists tend to look at the subjective experience of individuals” (Bleys, 2012, p. 358).

Later frameworks followed a different approach by classifying the indicators via their relationship to GDP along a continuum from traditional SNA accounting on one end to subjective well-being on the most progressive and opposite end (Bleys, 2012). As one of the best representations of this approach, Goossens’ (2007) framework proposed three categories: adjusting GDP monetarily to correct for missing social or environmental factors; supplementing GDP with additional non-monetized social and environmental factors that complete GDP; and replacing GDP with non-monetary indicators that directly assess well-being. Van den Bergh (2009) follows, sorting alternative indicators into four types: pragmatic accounting adjustments to GDP; a more elusive sustainable or “green(ed)” GDP; genuine savings across the sums of economic, human, and natural capital; and well-being composite indexes without monetary units (van den Bergh, 2010, p. 124). Costanza et al. (2004; 2014a) also follow the path of Goossen (2007) and specify the use of structural elements like composite indexes and indicator suites accordingly. In this scheme, indicators are split into categories of those that: adjust economic indicators to reflect social and environmental aspects (i.e., modifications to GDP, income accounts, capital accounts); bring together a multitude of aspects like life expectancy, income, housing, time use, or governance into a composite index; or directly measure life satisfaction through surveys (i.e., subjective well being) that form an index (Costanza, Kubiszewski, et al., 2014).

Bleys’ (2012) review of 23 alternative indicators yielded a framework that is more comprehensive and substantive than Goossens’ (2007) classification scheme. Rather than focusing primarily on the indicators’ relationship with GDP, Bleys (2012) categorizes according to the larger concepts of well-being, economic well-being (as a subset of broader well-being), and sustainability. Measures of well-being are subclassified according to one of three underlying concepts (utilitarianism, human needs, and capabilities) as well as by the use of objective versus subjective measurement techniques. Indicators that fall under economic well-being are subcategorized by type of income (economic income, sustainable income, and psychic income). Similarly, those measures that address sustainability are grouped under one of three areas: “three pillar” or triple bottom line; ecological (e.g. ecological footprint); or capital (human-made, natural, and social). The author recommends that clearly “any set of measures to monitor progress should include at least one indicator of each subcategory” (Bleys, 2012, p. 373).

In an even more extensive review, Barrington-Leigh and Escande (2018) surveyed 82 alternative indicators developed since the 1970s, which they grouped into four categories: systems of money-denominated accounts; unaggregated collections of indicators; indices; and measures oriented around subjective well being (Barrington-Leigh & Escande, 2018, p. 893). They noted that indicator development efforts initially took place at subnational or national levels, moved to the international context, and is most recently occurring in local communities that build accounts consisting mostly of objective indicators using existing statistical data sources but linked to specific community goals (Barrington-Leigh & Escande, 2018). A resurgence is occurring from indicators focused on “progress” or “sustainability” to “well-being” and “happiness” instead (Barrington-Leigh & Escande, 2018). They saw new growth in approaches incorporating subjective well-being, attributing this to new quantitative advances and more rigorous measures of happiness (Barrington-Leigh & Escande, 2018). The authors contend that indices whose weights are derived empirically using subjective well-being tools are the most promising innovations in the field (Barrington-Leigh & Escande, 2018).

1.5. What Makes a Good Indicator

The literature revolving around qualities of indicators is vast. A scan of the literature related specifically to measures of economic and social welfare, well-being, and sustainability yielded several common characteristics of what makes a good indicator. These desirable characteristics can be summarized as:

Relevant to assessing progress; valuable for measuring and monitoring progress towards desired goals and appropriately informing decisions. By choosing particular indicators, one is also determining what is important—one is defining goals (Costanza et al., 2009).

Valid and correctly and accurately reflecting the underlying concept that it is intended to capture; conceptually sound and able to capture relevant phenomena that do not skew the results (United Nations, 2007).

Sensitive to changes to the variables and trends over time; could be compiled for different points in time with existing time series tracks current condition, how that condition has changed or will change over time, and the condition of and changes in the forces affecting the system (Bleys, 2012; Costanza et al., 2009).

Understandable, clear, unambiguous, and easily interpreted (United Nations, 2007); ideally designed through collective efforts across multiple disciplines and based on the views of those whose well-being is to be measured (Fleurbaey & Blanchet, 2013).

Comparable and can be standardized; produces results that can be compared across settings using existing data sets (Bleys, 2012).

Practical, useful, reliable; having the institutional capacity and resources to monitor, collect, interpret, synthesize, and report data for decision-making (United Nations, 2007); underlying data are available in a timely fashion and at an appropriate scale and scope. Costanza (2009); data availability and data reliability can be weighed against indicator relevance (United Nations, 2007).

In addition, in social science research, good practice includes ensuring indicators are **disaggregated** at an individual level, in order to be able to capture differences based on gender, race/ethnicity, socio-economic status and other factors, where relevant.

1.6. Typologies of Beyond GDP Indicators

Indexes

In the Beyond GDP literature, single indicators that result from the collection and interpretation of primary data (e.g. sulfur dioxide emissions per year; employment rates) are rarely used independently (Thiry, 2015) and are instead functionally grouped or aggregated together into some type of index. Lacking harmonization of terms, authors may describe and label the same indicators differently (i.e., aggregate versus composite versus compound) depending on the aggregation process (Hák et al., 2012), however, the overall objective is the same. An index aggregates different metrics into one by scoring and weighting the underlying indicators; the general purpose is to "re-scale elementary components in order to ensure comparability and to aggregate them, with possibly unequal weights, to produce one figure" (Hák et al., 2012, p. 33). The resulting scalar value is calculated as a weighted sum or other aggregation of the set of components (Barrington-Leigh & Escande, 2018).

Indicators of social performance for Beyond GDP are typically gathered into a hybrid, composite index, and in many cases, GDP per capita or total household income is one component among others like unemployment, health, and poverty (Fleurbaey & Blanchet, 2013). Forming an index can capture a concept of progress or well-being in a single value, allowing a summary measure to be tracked over time, plotted easily, and communicated efficiently (Barrington-Leigh & Escande, 2018). The Human Development Index (HDI), one of the best known examples, is a geometric mean of normalized indices, i.e., one for each of the three components, one of which is already aggregated from its component measures (Barrington-Leigh & Escande, 2018). The HDI's approach is "perhaps the simplest because it does not rely on sophisticated theory," a key advantage to increase its popularity (Fleurbaey & Blanchet, 2013, p. xii)

Packaging data into indexes is a way of summarizing and simplifying complex, detailed, and often multidimensional information and provides “an overall picture of the state or performance of a system in a simple and explicit manner” (Wu & Wu, 2012) that is easy to interpret (Bracco et al., 2019). Decision-makers and the public lose interest rapidly if presented with more than a few indicators . Indexes can help guide decision-making as well as monitoring and evaluation decisions (Wu & Wu, 2012). Indexes facilitate the task of ranking alternatives over time internally as well as straightforward comparison across external units (e.g., countries) and over time periods (Bracco et al., 2019).

However, several authors raise caution about the use of indexes. Bracco et al (2019) warn that the three central steps of index formation (normalization, weighting, and aggregation) are “subject to significant value-judgment and do not always satisfy fundamental scientific requirements” (Böhringer & Jochem, 2007). While aggregate indexes present users with an overall number that is easier to interpret, the aggregation lessens the ability to pinpoint the underlying cause of a change in that overall number (Fioramonti et al., 2019). An index has potential to be misused if the underlying statistical or conceptual framework is not transparent or sound or if dimensions that are difficult to measure are left out (Bracco et al., 2019).

Dashboards

Of the many examples within the Beyond GDP literature, most measures are not aggregated into a single, scalar value but instead remain separate indicators, as those indicators are not naturally commensurable or easily converted into monetary equivalents to be aggregated (Barrington-Leigh & Escande, 2018). Instead, metrics are often collated into a suite of indicators representing multiple dimensions (e.g., environmental, social, and economic) and presented as a dashboard. The components on the dashboard can be organized by topic or theme, nested at different levels, and/or accompanied by narratives, but are not quantitatively summed (Barrington-Leigh & Escande, 2018). These systems avoid the final aggregation step, so the question: “what does this all mean?” is up to the user’s interpretation instead (Costanza et al., 2009).

Dashboards reflect “the multidimensional nature of sustainability and well-being” and are conducive to broader assessment (Bracco et al., 2019, p. 14).The number of dimensions included are not restricted and dashboard components can easily tie in with a wide range of targets and goals. Nevertheless, an extensive list of indicators can become overwhelming and complex (Barrington-Leigh & Escande, 2018) and difficult to interpret particularly “when the indicators differ both in amplitude and in the direction of change” (Bracco et al., 2019, p. 13). Dashboards lack the advantage of headline indicators, as decision-makers and the public lose interest rapidly if presented with more than a few indicators (Thiry, 2015).

Dashboards make it easier to identify explicit differences with respect to each single indicator within the collection as they remain disaggregated (Bracco et al., 2019). Yet because single indicators remain independent, the dashboard provides no indication of the relative importance or tradeoffs among them, but at the same time eliminates decisions about what weights to impose on each (Barrington-Leigh & Escande, 2018; Bracco et al., 2019).

Costanza et al. (2009) notes large numbers of applications of dashboards at municipal and national scales, a trend that is confirmed more recently by Barrington-Leigh and Escande (2018). Dashboards make information more accessible to average citizens and decision makers alike and “provides context to what might otherwise be obscure statistical quantities” (Barrington-Leigh & Escande, 2018, p. 19). When the indicators are tied to specific goals and trends, the dashboard becomes a useful tool for policy accountability (Barrington-Leigh & Escande, 2018). Granted, the “extreme richness” of dashboards (Thiry, 2015) combined with specificity to a particular location or context, makes general comparison difficult across broader, especially international, scales (Bracco et al., 2019)

Adjusted economic measures

This typology includes alternative indicators of economic well-being known by a wide range of terms including: green accounting, green GDP, genuine progress, index of sustainable economic wealth, adjusted net savings, inclusive wealth, comprehensive wealth, corrected national income accounts, money-denominated accounts of progress, augmented GDP, augmented accounts, natural capital accounting, system of environmental and economic accounting, satellite accounts, and so on. The common characteristic is the attempt to correct conventional economic variables by accounting for environmentally and to a lesser extent, socially related dimensions using monetary approaches (Bracco et al., 2019). More broadly, traditional economic performance indicators such as GDP or national savings rates are adjusted by including monetized environmental and social factors (Bleys, 2012; Goosens et al., 2007). GDP itself is an index expressed in terms of monetary flows, yet these measures “grew around the calculation of a more complete accounting of investments and production than that which governments were willing to make” (Barrington-Leigh & Escande, 2018, p. 901). These monetary approaches are at the extreme opposite of the composite approaches mentioned above insofar as they are the most demanding in terms of background in economic theory (Fleurbaey & Blanchet, 2013)

These indicators are typically “denominated in units of currency representing consumer expenditure of GDP with additions and subtractions for non-market work, environmental degradation, and other normative categories” (Barrington-Leigh & Escande, 2018, p. 901). Presented as a single scalar value in familiar monetary units, the information can be easily communicated and easily digested by both policy makers and the public (Bracco et al., 2019). Moreover, the results are directly comparable with GDP in terms of commensurable units and denominations (Barrington-Leigh & Escande, 2018) and can be compared between countries and across time (Bracco et al., 2019). This is assuming of course that all changes in natural and other capital forms can be valued accurately, particularly when the valuation of non-market ecosystem services can be particularly tricky (Bracco et al., 2019).

The subset of indicators referred to as green accounting start with the national accounts and GDP as the foundation and then “add or subtract quantities in an attempt to address and/or correct some of the weaknesses of GDP” (Costanza et al., 2009, p. 11). The case for rearranging the accounting protocols is relatively straightforward (Costanza et al., 2009) because some expenditures that increase GDP (e.g. pollution clean up costs) should actually be counted as harmful or defensive in nature. Green accounting also attempts to assign monetary value on social and environmental “externalities” of economic growth (Hoekstra, 2019).

Other indicators within this typology take the “capital approach” (Hoekstra, 2019) and expand the stocks of capital used in conventional accounting measures to include natural, financial, physical, and human (Bracco et al., 2019). These capital stocks can be used for the well-being of the current generations or can be left to future generations. Clearly, this approach is attractive when the aim is to stress the intergenerational nature of sustainability. To create an index, all these capital stocks need to be measured in monetary terms (Hoekstra, 2019). In 2012, the UN, OECD, and World Bank adopted the System of Environmental Economic Accounting (SEEA), an international statistical standard for capital accounting. Nearly 100 countries publish environmental stocks and flows using the SEEA methodology and all EU members are required to produce annual environmental accounts (Hoekstra, 2019). More recently, in March 2021 the UN expanded the central framework of the SEEA to include an Ecosystem Accounting piece (i.e., SEEA-EA) with a greater focus on capturing the ecosystem services that come from natural capital accounts.

Sustainability indicators

Sustainability indicators provide information on the “state, dynamics, and underlying drivers of human–environmental systems” using environmental and socioeconomic measurements or observations (Wu & Wu, 2012, p. 70). Generally, they incorporate economic, environmental, and social domains, as these three pillars of sustainability (i.e., the triple bottom line) define sustainable development (Wu & Wu, 2012). Several underlying assumptions contribute to the development of indicators within the typology of sustainability indicators. Hoekstra (2020) notes that many initiatives are based on the Brundtland report definition of sustainability, “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (p 10). Fleurbaey & Blanchet (2013) comment that in addition to measuring the well-being of the present generation, developers of alternative indicators would naturally “think of the hazards to future generations induced by unfettered economic growth” (Rockström, n.d., p. xii), the originator of the concept of planetary boundaries, brings in the idea of biophysical limits and believes that economic growth, defined in terms of GDP, “is unsustainable under all circumstances—irrespective of whether planetary boundaries put biophysical guardrails around development or not” (Rockström, n.d.). Other initiatives argue that it is also important to incorporate two dimensions of time into current well-being (‘here and now’) and sustainability (‘later’)” (Hoekstra, 2019).

Yet another debate centers on whether sustainability allows for substitution between natural and human-made (manufactured) capital and how closely an indicator aligns with the principles of weak versus strong sustainability. Weak sustainability assumes “any level of natural capital depreciation can potentially be offset by a sufficiently high rate of physical or human capital accumulation”(Fleurbaey & Blanchet, 2013, p. 23). While weak sustainability permits mutual substitutability among the three dimensions, strong sustainability does not (Wu & Wu, 2012). An indicator focused on weak sustainability always assumes the possibility of substituting produced capital goods for natural ones “even when stocks for the latter become very low” (Fleurbaey & Blanchet, 2013, p. 23).

Sustainability indicators can take on different forms (indexes, dashboards, economic adjustments) as per Fleurbaey & Blanchet (2013). Granted, discrepancies among sustainability indicators arise from the “different conceptualizations of, and emphases on, key dimensions of sustainable development and their linkages, as well as the different ways of grouping and aggregating indicators”, and furthermore “none is adequate to gauge the multiple dimensions of sustainability by itself” (Wu & Wu, 2012, pp. 71–73). Nevertheless, one well-known initiative in particular illustrates the efforts taking place within this typology: the ecological footprint.

The ecological footprint (EF) is an example of an index using biophysical measures to calculate the area needed to satisfy human consumption. The EF compares each country’s direct or indirect pressure on natural resources either to its own resources or to the average of resources available per head at the world- wide level (Hoekstra, 2019). The EF has been used as a stand-alone index of environmental sustainability and is also incorporated into other composite indicators. For more than two decades, EFs have been calculated for most nations and many subnational regions. The EF is intended as a resource management tool to assess “whether and to what extent an individual, city, or nation is using available ecological assets faster than the supporting ecosystems can regenerate those assets” (Costanza et al., 2009, p. 15). This indicator is generally aligned with the strong view of sustainability or the idea that “sustainability requires a separate preservation of all environmental assets, whatever the accumulation of other produced assets” (Fleurbaey & Blanchet, 2013, p. 24).

Subjective well-being (SWB) indicators

Up until the early 2000s, well-being was predominantly measured through objective indicators such as life expectancy, rates of disease, and GDP. Yet these were only proxies for well-being, ironically identified through the subjective judgment of the decision makers who chose them (Costanza 2009). Cultural differences constrained the ability to compare these results across different ethnicities, gender, age, religion, and location (Costanza 2009). Developments in empirical studies of subjective well being (SWB) further questioned the suitability of absolute individual income as a proxy for individual well-being (van den Bergh, 2009), such that these SWB measures of progress fall squarely into the category of Beyond GDP.

Interest in SWB measures has jumped significantly over the last two decades given the development of happiness data and related econometric techniques building on over 40 years of research in the fields of psychology and sociology (Fleurbaey & Blanchet, 2013; Kullenberg & Nelhans, 2017). From an economist’s point of view “it is quite a revolution, in view of the long skepticism about such measures in the discipline in most of the twentieth century” (Fleurbaey & Blanchet, 2013, p xiv).

Economists have been interested in using life satisfaction for some time (Dolan et al., 2011) and SWB indicators now comprise a growing fraction of progress metrics (Barrington-Leigh & Escande, 2018). The OECD in 2015 published a handbook on how to measure subjective well-being and Eurostat now includes quality of life (QoL) measures in various dimensions in a dashboard of indicators (Hoekstra 2019). Research on subjective indicators is receiving increasing attention by policy makers as well (Muraca and Schmelzer, 2017).

Barrington-Leigh & Escande (2018) attribute the increased attention on “human-based measures” in general to increased rigor in the quantitative measures of happiness as well as new insights on the importance of such links.

The standard approach relies on survey techniques that come from the field of happiness economics and have been in use since the 1950’s. Layard (2010) says there are many different ways to measure happiness and life satisfaction; measures can be based on a single question or on multiple questions to decrease errors in measurement. The best known tool is Gallup World Poll’s Cantril Ladder. Respondents are asked to assign values on a 0-10 scale for questions related to three broad categories of measures: evaluation of life satisfaction; experience resulting in happiness or worry; and ‘eudemonic’ theory related to purpose and worthiness (Dolan et al., 2011). Typical questions would include ((Dolan et al., 2011, p. 14):

- *Overall how satisfied are you with your life nowadays? (evaluation)*
- *Overall, how happy did you feel yesterday? (experience)*
- *Overall, how anxious did you feel yesterday? (experience)*
- *Overall, to what extent do you feel that the things you do in your life are worthwhile?” (eudemonic)*

Responses are then combined into a single index using weights that reflect their average impact on answers to the single question. Ideally, measurements would cover a substantial period of time (Layard 2010). These subjective well-being indices hold several benefits compared to objective or other measures. They carry a headline scalar (i.e., aggregated) index which eases communication. Their weighting scheme is less arbitrary because values are stated subjectively rather than using objective measures that assume values and weights. Overall, “they do not suffer as much from the drawbacks related to accountability and theoretical foundation” (Barrington-Leigh & Escande, 2018 p 908).

1.7. Examples of Beyond GDP Indicators

Stiglitz et al. (2018) observed three common features of Beyond GDP indicators. All frameworks used a multi-dimensional approach combining economic data on living conditions with a wide range of quality of life factors. Varying degrees of consultation with wider audiences during the selection process helped to legitimize the resulting framework. Finally, most indicators use measures of people’s subjective well-being as one of the key components, complementing rather than replacing objective indicators. Similarly, three common challenges when measuring progress are to go: “beyond the market” to recognize that well-being is multi-dimensional; “beyond averages” to account for inequities in distribution of income or well-being outcomes; and “beyond the here and now” to understand intergenerational impacts of economic growth on environmental sustainability and resilience (Llena-Nozal, Ana et al., 2019, p. 12).

When surveying the landscape of Beyond GDP indicators, it is important to assess whether and how potential candidates go “beyond the market, averages, and the here and now.” The following table offers a small sample of Beyond GDP indicators and is by no means an exhaustive list, as hundreds of possibilities exist. Entries were chosen to reinforce the key findings within this literature review, illustrate best practices, and represent the core concepts underlying Beyond GDP indicators. The attributes were chosen to illuminate gaps and identify weaknesses not just in this small sample, but to help inform the process of choosing other alternative indicators as well. Attributes include: type of indicator; relation to GDP; approach in terms of objective and subjective measures; domains of sustainability; inclusion of distribution and inequality; and other missing factors like unpaid work. The table was informed by and adapted from two sources in particular (Berik, 2020; Hák et al., 2012).

Each indicator in Table 1 (Berik, 2020; Hák et al., 2012) is evaluated as an adjustment, supplement, or replacement to GDP (Goosens et al., 2007). The Genuine Progress Indicator (GPI) for example, represents an accounting adjustment as it is tracked in monetary terms and starts with personal consumption expenditure, the same component at the heart of GDP. It "adjusts" according to accounting protocols, recognizing that other economic, environmental, or social factors are missing (or incorrectly included) in GDP. The Human Development Index (HDI), Better Life Index (BLI), World Happiness Report (WHR), and Aloha+ Challenge all fall within the supplemental category because they rely on GDP as one component within the index/dashboard, but do not produce aggregate outcomes in monetary units. Replacement indicators in this scenario are represented by the Ecological Footprint (EF) and Happy Planet Index (HPI); neither incorporates GDP or other economic measures, and instead both focus heavily on biophysical measures plus, in the case of HPI, life expectancy and subjective well being.

Table 1. Examples of Beyond GDP indicators

	Indicator	GPI	Happy Planet Index (HPI)	Ecological Footprint	Human Development Index (HDI)	Inequality-adjusted Human Development Index (IHDI)	OECD Better Life Index (BLI)	World Happiness Report	Aloha+ Challenge
Link to GDP	Adjust	X							
	Supplement				X	X	X	X	X
	Replace		X	X					
Application (level of impact)	International		X	X	X	X	X	X	
	National	X		X					
	Local	X		X					X
Assessment Approach	Objective	X	X	X	X	X	X	X	X
	Subjective		X					X	
Type of Indicator	Dashboard						X		X
	Index	X	X	X	X	X	X	X	
Non-GDP Measures:	Inequality	X	X			X	X	X	
	Environment	X	X	X			X		X
	Non-Market Activities	X					X		
	Unpaid Work	X					X		

The application is the level at which impact is taking place in terms of measurement, comparison, or policy. The examples here of indicators used at the international level are those deployed by large international organizations (the OECD's BLI and World Bank's HDI). The EF has the capacity to be deployed at all three levels, even with an option to calculate individual footprints. Applications of GPI have taken place at both the national and subnational levels, but cannot be used for comparison across those scales. Although the locally developed Aloha+ Challenge dashboard is not deployed outside of Hawai'i, Hawai'i is featured as a UN Local 2030 hub for its work on local implementation of the 17 UN Sustainable Development Goals (SDGs). The UN SDGs framework is a dashboard itself with 169 associated targets and lessons learned from the Aloha+ Challenge will be shared with other communities internationally that are developing similar dashboards.

The examples in Table 1 show either objective or subjective assessment approaches or both. This attribute specifically means the use or non-use of instruments that measure subjective well-being and does not address subjectivity that may be embedded in indicators, for example the choice of weights in an index. While the use of SWB measures in the field is gaining, within this sample only the HPI and the WHR incorporate them; both use data from Gallup World Poll surveys.

Type of indicator refers to the structural component of the indicator, using the two broad categories of index (with some method of aggregation) or dashboard (a suite or collection of unaggregated indicators). The OECD's BLI is particularly interesting because although its collection of 11 indicators is presented as a dashboard, it offers additional functionality as an index to users who then assign weights to each of the indicators as they deem appropriate and consequently generate an overall ranking.

The attributes under the non-GDP measures are additional variables not accounted for in GDP but are highlighted in this table to show efforts that these alternative indicators make to address certain weaknesses in GDP. In Table 1, only GPI and BLI incorporate non-market activities and unpaid work as ways to address GDP weaknesses. The two take significantly different approaches; GPI monetizes the costs or benefits of each to make accounting adjustments while BLI works as an index, normalizing and then ranking the data.

Beyond GDP indicators in general are criticized for not doing enough to address inequality, and even those that do, only get at the issue from the economic perspective. Peterson (2014) suggests that Beyond GDP indicators need to go beyond economic inequality (wealth, income, consumption), to recognize non-economic inequalities (in health and education), gender inequality, and subjective inequality (perceived inequality) (Peterson, 2014). The examples in this table approach inequality in different ways, if at all. GPI focuses on economic inequality, using coefficients to adjust for uneven distribution. As one out of four factors, Happy Planet Index (HPI) looks at how uneven the distribution is between people within a country based on their life expectancy and reported life satisfaction. The Inequality-adjusted Human Development Index (IHDI) adjusts for economic, health, and education inequality. It is considered to be the most comprehensive well-being index in terms of inequality, which is why it was chosen to be included in this table.

Environment is one of the three pillars of sustainability (i.e., environment, economics, and social). At times, however, the tendency is towards a greater focus on biophysical factors and less so on social or economic. The Ecological Footprint (EF) focuses exclusively on the biophysical demands that an individual's consumption places on nature, while the Happy Planet Index (HPI) starts with other factors for individuals such as inequality adjusted life satisfaction and life expectancy relative to that person's EF. Other indicators such as HDI and the WHR do not incorporate environmental factors at all.

1.8. Beyond GDP in Hawaiʻi

In addition to the resources reviewed within the broader Beyond GDP context, there are many currents of heterodox economic thinking that have informed our work on GPI and that have shaped contemporary and complementary data initiatives here in Hawaiʻi. This includes research on wealth from a Native Hawaiian perspective (e.g,. Aloua, 2021; Baker, 2018; Williams, 2020) as well as broader rethinking of history, values and Native livelihoods (E.g. (Daviana Pomaikaʻi McGregor et al., 2003; Davianna Pōmaikaʻi McGregor, 2007). Other current contemporary social and political movements include the movement for aloha ʻāina, as well as how these different movements have articulated their responses to the COVID-19 crisis (e.g. the Feminist Economic Recovery Plan, ʻĀina Aloha Economic Futures etc.). The following initiatives outlined below are not an exhaustive list but represent a set of movements and initiatives aimed at gathering and synthesizing multiple indicators that aim to capture economic, social and ecological wellbeing in the context of Hawaiʻi. It is with these initiatives that GPI occupies the greatest shared space.

Hawaiʻi Green Growth Aloha + Challenge Dashboard

The Aloha+ Challenge Dashboard is an online open-data platform to track progress, provide accountability and ensure transparency on Hawaiʻi's sustainability goals. The Dashboard was developed through a multi-year process that engaged hundreds of diverse public, private, and community stakeholders across the state in partnership with the four counties to identify agreed statewide indicators. The dashboard showcases a wide variety of Indicators that fall under six goals: natural resource management; clean energy; waste reduction; local food; smart, sustainable communities; and green jobs and education. GPI is already listed as a potential indicator under the Smart, Sustainable Communities and serves as a placeholder for further data collection and reporting. The 2020 Benchmark Report provides a recent update and review.

UH Center of the Family/DBEDT Quality of Life in Hawaiʻi

In 2008, under a contract with the Hawaiʻi Department of Business, Economic Development, and Tourism (DBEDT), the University of Hawaiʻi Center on the Family (COF) created a set of community quality of life (QOL) measures for the state to assist economic initiatives, state and county planning, and social service programs to identify trends and critical factors relating to the community's wellbeing. In 2019, DBEDT published an update on the 27 QOL indicators, many of which overlap or complement GPI efforts.

Aloha United Way ALICE Reports

Aloha United Way commissioned ALICE: A Study of Financial Hardship in Hawai‘i to help identify those across our state who are struggling to make ends meet, and to understand the enormity of this issue and the obstacles these families and individuals in our communities face. ALICE is an acronym for Asset Limited, Income Constrained, Employed. In Hawai‘i, there are 148,771 ALICE households (33 percent), while another 41,619 households (9 percent) live below the poverty level. In total, 42% of Hawai‘i households are ALICE and below. The ALICE methodology and indicators overlap particularly well with the economic indicators within the GPI.

Vibrant HI

Vibrant HI works towards data justice with a community focus on Hawai‘i Island in response to ALICE report findings. Efforts to formulate ground-up indicators drawn from community feedback processes. Complements GPI work by utilizing a community-driven methodology to define and ground economic goals/aspirations within a Hawai’i island and a Native Hawaiian perspective. This work informs the Beyond GDP and GPI processes as it represents community-based indicator development with unique perspectives on culture and localized wellbeing.

Hawai‘i Data Collaborative

The Hawai‘i Data Collaborative is working to promote a culture of data-driven decision making in Hawai‘i by making data for solving our pressing challenges more accessible, relevant, and meaningful. According to HDC’s mission “We believe that data and evidence are essential to informing our understanding of what is happening, why it is happening, and what we should do about it. We engage in collaborations to dive deep on topics of critical importance, building data and evidence capacity where it is needed the most.” HDC and GPI utilize similar data sources already with potential to engage in further discussion about data and methods, particularly given HDC’s new project to focus on households.

Hawai‘i Sustainability 2050

The Hawai‘i 2050 Sustainability Plan was published in 2008 in accordance with Act 8, Special Session Laws of 2005 with requirements for regular 10 year status updates. A 2018 report reviewed the data collected over the course of this ten year measurement of Hawai‘i’s progress toward sustainability according to the Hawai‘i 2050 Sustainability Plan’s 5 goals, 9 “2020 benchmarks”, 22 strategic actions, and 55 indicators, ultimately finding that Hawai‘i continues to struggle with these same issues. In July 2021, the State of Hawai‘i Office of Planning’s Statewide Sustainability Program released another update to the Hawai‘i 2050 Sustainability Plan entitled Charting a Course for the Decade of Action (2020-2030). The report serves as the state’s sustainability and climate strategic action plan; aligns the state’s goals, policies, and actions with the UN SDGs; and recommends sustainability and climate change actions for the coming decade. Further discussions on overlapping indicators and data between GPI and the 2050 Plan can identify opportunities for collaboration.

ʻĀina Aloha Economic Futures

ʻĀina Aloha Economic Futures (AAEF) was created in March 2020 when a group of Native Hawaiian community members from diverse professional backgrounds collaborated to draft a values declaration and action agenda offering a vision for growing a stronger Hawaiʻi that called forth bold leadership to achieve this future. According to the AAEF "Policy Playbook" and through an ongoing process of community engagement and working groups, AAEF is forwarding a community-created vision for our economy and empowering leadership accountable to that vision as we set a course together for Hawaiʻi's economic resilience. So far, 2800 organizations and individuals have signed on to the AAEF principles and onto working groups. Potential for rich exchanges of ideas and data exist as both the AAEF and GPI move forward, particularly with respect to the "Circular Economy" working group.

1.9. Moving Beyond "Beyond GDP"

The Beyond GDP movement has succeeded in gaining general agreement that GDP is not a measure of wellbeing, inequality, or sustainability, and is mistakenly used as a proxy for welfare. Hayden (2021) attributes "decades of work questioning the primacy of GDP and developing alternative measurements" to a "growing acceptance that GDP is not an adequate measure of wellbeing or national success" (Hayden, 2021, p. 123). This awareness has spawned many types of alternatives, from metrics of subjective wellbeing, to dashboards representing suites of indicators, to composite green accounting indicators. Hoekstra (2018) notes that since national income started in the 1930s, hundreds of alternatives have been proposed to deal with criticisms from the Beyond GDP corner, all of which propose to be a better compass for guiding social policy.

Unfortunately, adopting, measuring, and reporting on Beyond GDP indicators is no guarantee that policy changes will take place. Hayden (2021) refers to the term "indicator fantasy" to describe the aspirations of the Beyond GDP movement; the "assumption that simply producing new measurements will, on its own, lead governments to take notice, resulting in policy change—perhaps even transformative change," spurring evidence-based decisions and policy making (Hayden, 2021, p. 120). Such information is, however, only one relatively weak factor relative to others that influence policy making such as "ideology, institutions, and institutional constraints" (Hayden, 2021, p. 125). Indicators alone are not enough to drive policy reform to better incorporate inequality and sustainability or activate larger transformations such as movement from a growth based economy to one that can safely and sustainably operate within planetary bounds.

Hayden (2021) sees limited success in how Beyond GDP indicators fare in relation to goals of either reforming or transforming current economic systems. Success is defined along a continuum of political use, conceptual use, and instrumental use, with instrumental use being the highest level of integration. Instrumental use is achieved when indicators are directly linked to policy decisions. Just a few promising examples of successful uptake exist currently: the inclusion of an alternative indicator into cost-benefit analysis, the launch of wellbeing budgets, and mandated use in policy analysis (Hayden, 2021). *See the Well Being Economy and Doughnut Economy boxes below.*

The current debate is what to do next to move further beyond “Beyond GDP.” Bleys and Whitby (2015) and Hoekstra (2019) all agree on next steps to increase the policy value of alternative indicators: 1) harmonize the terminology, metrics, and accounting frameworks; 2) extend macroeconomic models to include factors of wellbeing; and 3) reframe the public narrative so “wellbeing” is no longer a vague concept. Bleys and Whitby (2015) also call for “indicator and researcher entrepreneurs” to promote the use of new and existing indicators and combat distrust of aggregation. Hoekstra (2019) insists we need to get past a beyond-GDP cottage industry, where every camp creates new indicators. Following lessons from the success of GDP, we need to foster “an institutionalized community with a clear goal and coherent structure based on a common language” (Hoekstra, 2019, p. 17) within the existing multidisciplinary group. A coherent macroeconomic structure would comprise an accounting framework (like the System of National Accounts) and (quality and system) indicators and create a narrative that is similar to what macroeconomists use when discussing components of GDP and macroeconomy. Finally, Hoekstra (2019) proposes a multidisciplinary measurement framework (entailing global environmental, societal, economic, distribution, quality accounts), more akin to a dashboard, not a composite index like GPI.

WHAT IS THE WELLBEING ECONOMY?

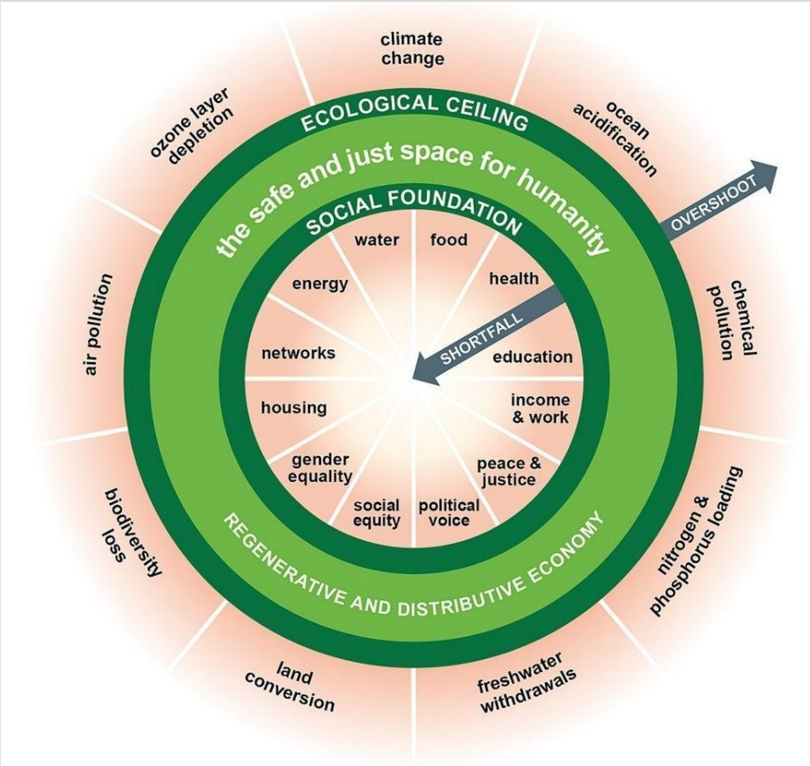
The Wellbeing Economy is a model for the future on what “better” can look like. It is a movement that strives to have an economy that delivers social justice on a healthy planet. The Wellbeing Economy Governments (WEGo) was officially launched in 2018 at the OECD’s World Forum. WeGo and the Wellbeing Economy Alliance (WEAll) is a collaboration formed to catalyze a cooperative, harmonized, and effective approach to creating Wellbeing Economies. Governments of Scotland, Iceland, New Zealand, Wales and Finland aim to have business, politics, and economic activity exist solely to deliver collective wellbeing rather than having GDP growth as the top priority. The Wellbeing Economy has 5 key components for a universal good life because the current economic system is, in short, unfair, unsustainable, unstable, and unhappy.

1. **Connection**: A sense of belonging and institutions that serve the common good.
2. **Dignity**: Everyone has enough to live in comfort, safety, and happiness.
3. **Fairness**: Justice, in all of its dimensions, at the heart of economic systems, and the gap between the richest and poorest greatly reduced.
4. **Participation**: Citizens are actively engaged in their communities and locally rooted economies.
5. **Nature**: A restored and safe natural world for all life.

The Wellbeing Economy has been prioritized through New Zealand’s wellbeing budget, Scotland’s ambitious climate change legislation and National Performance Framework, Wales’ world- leading Future Generations Act, and Iceland’s framework of wellbeing indicators (Abrar, 2021; Chrysopoulou, 2020; WEAll, n.d.).

WHAT IS THE DOUGHNUT MODEL?

Kate Raworth, an English economist working for the University of Oxford and the University of Cambridge created a new economic model for the 21st century that aims to balance essential human needs with planetary boundaries. The “doughnut” has two concentric circles comprising of 12 societal foundations such as water, peace and justice, and social equity, with the outer ring representing 9 of earth's limits such as with air pollution, biodiversity loss, and land conversion. The goal of the model is to create a space in the middle of the doughnut where humanity can thrive between the ecological ceiling and the necessary social foundations. Raworth published Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist in 2017 and it has gained international recognition. Amsterdam for example has embraced the doughnut as a way to recover from the COVID-19 crisis. The city is trying to put the theory into practice with employment strategies, sustainable political action, and infrastructure projects that use bio based/recycled materials. Other cities have followed suit, with Copenhagen adopting the doughnut last June. Places in New Zealand, Belgium, Canada, and Oregon in the U.S. are expected to adopt their own versions. Raworth hopes that the doughnut will replace the never-ending GDP growth ideal that labels environmental issues as externalities rather than a necessary component of 21st century thinking (Boffey, 2020; Nugent, 2021; Raworth, 2013)



2. Genuine Progress Indicator (GPI) Literature Review

GPI is an indicator of economic welfare representing the costs and benefits of economic activity. It has evolved since the 1980s, with the current debate centered on how to standardize methods and achieve policy impact.

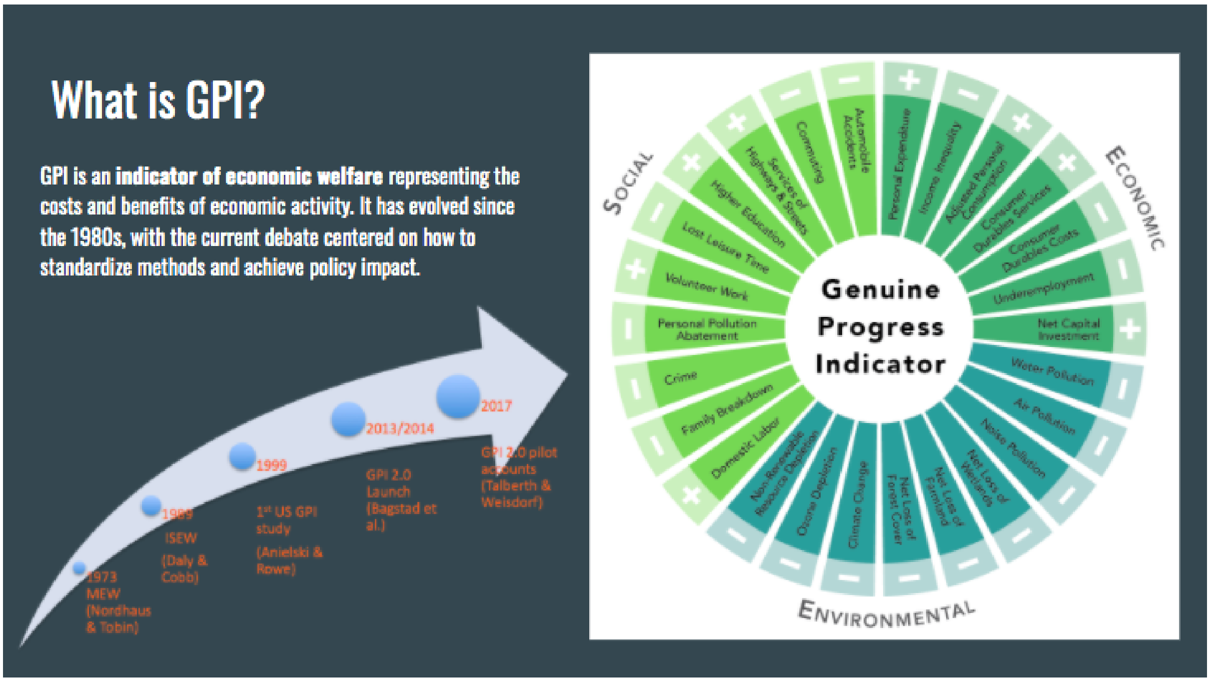
2.1. History of GPI

GPI derives from decades of effort to build an indicator of economic welfare that accounts for both the benefits and costs of economic activity.

Information on the size and direction of the macroeconomy is critical to designing and evaluating policy. National income and product accounts provide such information, however, as we summarize in the section above on Beyond GDP, the leading policy indicator GDP is a poor metric of progress. The marginal costs of economic growth can outweigh the marginal benefits, leading to “uneconomic growth” (Daly, 1987). The general assumption is that economic consumption results in utility, but not all consumption activities are welfare-enhancing, and many have costly effects on third parties (externalities) (Bleys, 2012). Increasing inequality, loss of quality leisure time, natural resource depletion, environmental degradation, and expenditures on protecting ourselves from our own success can all be byproducts of economic growth. Extending the logic of GDP’s founding father, Simon Kuznet, that not all components of GDP contribute to welfare and thus should not be considered income, so-called green accounting indicators aim to rigorously assess which economic activities increase welfare, which decrease welfare, and which are intermediate activities, to thereby account for both sides of the balance sheet (credits and debits to welfare) without double counting. This section summarizes efforts to develop a singular composite index of the macroeconomy that better reflects welfare by accounting for *both* the utility and disutility generated from economic activity.

A series of indexes of economic welfare have been progressively developed over the past 50 years to address the shortcomings of GDP. A major advantage of these alternative measures of economic welfare is that they are expressed in monetary terms, and thus can be directly compared to GDP (Bleys & Whitby, 2015). In 1972, the year many economists cite as the beginning of Beyond GDP (Hoekstra, 2019), Yale economists Nordhaus and Tobin created the Measure of Economic Welfare (MEW) (Nordhaus & Tobin, 2018). Building upon the financial transactions in GDP that contribute to wellbeing, the MEW adds in the value of non-market leisure time and home-based work, and deducts environmental damages. In 1989, Daly and Cobb (1989) revised the MEW into the Index of Sustainable Economic Welfare (ISEW), over time taking into account a broad array of harmful effects of economic growth while excluding expenditures on national defense that are defensive and thus not welfare-enhancing. The Genuine Progress Indicator (GPI) is the latest iteration in this series of measures of economic welfare (Figure 1).

Figure 1. GPI timeline and indicators



GPI was initially coined in 1994 by Redefining Progress, a non-profit public policy institute based in San Francisco (Cobb, Clifford et al., 1995). GPI is an extension of the ISEW; it includes a wider range of welfare measures, but is by and large the same metric as ISEW. The literature from the US and Asia-Pacific Region uses the label GPI, while the rest of the world tends to use ISEW (Bleys & Whitby, 2015). Closely following the ISEW, and like GDP, the GPI uses personal consumption expenditure as its baseline. To reflect the distribution of economic growth, personal consumption is adjusted for income inequality. Unlike GDP, which adds expenses to income instead of deducting them, GPI tallies costs of producing economic benefits (e.g., pollution) separately from the benefits (e.g., production of goods) (Cobb et al., 1999). While personal consumption expenditures capture the market value of products and services consumed in the economy, GPI also adds the value of non-market consumption. Defensive expenditures, social costs, and environmental depletion and degradation are monetized and deducted.

While the list of indicators has adjusted over time as the GPI has developed, the **25 indicators** within the 1999 update remain largely intact (Cobb et al., 1999):

1. Personal consumption
2. Income distribution
3. Value of housework and parenting
4. Value of volunteer work
5. Services of consumer durables
6. Services of highways and streets
7. Cost of crime
8. Cost of family breakdown
9. Loss of leisure time

10. Cost of underemployment
11. Cost of consumer durables
12. Cost of commuting
13. Cost of HH pollution abatement
14. Cost of auto accidents
15. Cost of water pollution
16. Cost of air pollution
17. Cost of noise pollution
18. Loss of wetlands
19. Loss of farmland
20. Loss of old growth forests
21. Depletion of nonrenewable resources
22. Cost of long-term env damage (CC)
23. Cost of ozone
24. Net capital investment
25. Net foreign lending or borrowing

2.2. Theoretical foundations

GPI theory is based on Fisher's notion of subjective satisfaction, departing from previous indicator's focus on Hicks' "maximum sustainable consumption"

Daly and Cobb (1989) relied on Hick's theory of income when developing the ISEW. Specifically, they linked sustainable economic welfare to Hicks' (1939) notion of maximum sustainable consumption (Van der Slycken & Bleys, 2020). Hicksian income is the maximum amount one can spend in a given period without impoverishing oneself, i.e., consumption plus capital accumulation. A rough approximation of Hicksian income is derived by subtracting the amount of production dedicated to overcoming the depreciation of human-made capital (an amount that is thus not available for consumption) from GDP; this is also known as Net National Product. In the ISEW, Daly and Cobb (1989) extended this to account for defensive expenditures, that are by definition not welfare enhancing, and depletion of natural capital. Daly and Cobb drew on previous welfare compilations, adding adjustments for the cost of inequality for instance, as well as the benefits of public expenditures, the costs of environmental degradation, and change in capital, among other components (Van der Slycken & Bleys, 2020).

Lawn (2003) put forth an *ex post* theoretical framework for ISEW/GPI, arguing that Fisher's (1906) concepts of income and capital are more appropriate for GPI than Hicks'. Fisher considered the subjective satisfaction (i.e., utility satisfaction) enjoyed by consumers as "psychic income". He argues that this satisfaction is the ultimate good produced by an economy and not the goods produced in a given year (Bleys & Whitby, 2015; Lawn, 2003). Psychic disservices (labor, anxiety, annoyances, dissatisfaction, or other negative experiences suffered in the pursuit of desirable experiences) are then subtracted to measure the net psychic income. Lawn (2003, 2008) extends Fisher's net psychic income to account for the costs of economic production on ecosystems' capacity to deliver source and sink services, labeling it "entropic net psychic income" after Brennan (2008) to acknowledge the input of low entropic resources from the environment to the economy, and outputs of high entropic waste from the economy into the environment. Operationally, adopting Fisher's psychic income requires recording positive service flows from ecosystems, as well as deducting lost natural capital service flows (Van der Slycken & Bleys, 2020).

Fisher keeps income and capital separate; psychic income flows should be recorded, but not the changes in capital stocks from which those income flows derive (Van der Slycken & Bleys, 2020). In contrast to Hicksian income, Fisherian income counts all consumption as income, even if it reduces capital stock. Investments play a role, but only to maintain stocks from which consumptive services flow (Van der Slycken & Bleys, 2020). The psychic enjoyment of life depends predominantly on the quantity, quality, and distribution of human-made capital, more so than the rate of production of those goods (Lawn, 2003). Production of goods and services (i.e., GDP) is a means to maintain welfare-generating human-made capital stocks. By keeping income and capital separate, Fisher highlights how compensating for depreciating human-made capital through economic production is really a cost, not a benefit, and that such production requires exploitation of natural capital (Lawn, 2003).

Strengths of GPI

> **<u>GPI, which can be decomposed to its component parts, is a transparent accounting of the costs and benefits of economic activity and a good indicator of economic welfare.</u>**

Good indicator of economic welfare. Advocates of GPI have long pointed out that it is an imperfect indicator, but a vast improvement over GDP in terms of its representation of welfare (Kenny et al., 2019), and thus far superior for guiding policy. In his ex post theoretical justification for GPI and subsequent articles, Lawn (2003, 2008) argues that GPI is a good indicator of economic welfare, able to assess whether growth is "uneconomic" (i.e., GDP growth no longer correlates with an increase in welfare), and signal if an economy's scale is excessive.

Decomposable. GPI is not meant as a policy goal itself, but rather a starting point for discussion about the directions in which society can progress (Kenny et al., 2019). The individual components of GPI signal which impacts of economic activity are driving economic welfare to increase or decrease. The composite is easily decomposed into its parts, so one can track trends in each, not just the overall economy (Bagstad et al., 2014). Such detail provides policymakers with information and can guide action to halt losses or enhance gains, even if it does not provide information on the forces underlying those changes (Kubiszewski et al., 2013).

Familiar and transparent. GPI is a composite index, a single number articulated in monetary terms. It is, therefore, familiar to economists and policymakers (Bagstad et al., 2014). It provides a transparent, integrated accounting framework to comprehensively assess the benefits and costs of economic activity (Anielski, 2001; Bagstad et al., 2014).

Critiques of GPI relate to its indicators and their valuation, as well as its theoretical justification.

Arbitrary components. GPI's components are intended to reflect a consensus of what is important to welfare, but many components that have been included have debatable welfare implications (Berik, 2020), while many important dimensions of economic well-being are excluded (Kubiszewski et al., 2013). Kubiszewski et al. (2013, p. 58) emphasize that GPI is not meant to reflect all welfare-related factors, it is "confined to measuring the total economic welfare generated by economic activity" as its central purpose. Factors that may or may not enhance economic welfare, such as political freedom or education, should not be included in GPI as they are already reflected in the final welfare benefit (Kubiszewski et al., 2013).

Inappropriate valuation methods. GPI deals with non-market components, which are sensitive to assumptions about how to value the welfare contributions of these components (Berik, 2020). The use of valuation methods to assign prices to the monetary cost and benefit of components has drawn significant fire. For instance, GPI researchers have applied a cumulative cost approach for some of the ecosystem components to reflect the ongoing cost of the historical, permanent loss of natural capital (Kubiszewski et al., 2013). New research suggests that a discounted stream of foregone future benefits should be deducted the year the capital is destroyed, rather than the cumulative loss since some arbitrary past baseline year (Talberth & Weisdorf, 2017). Other critiques relate to the use of consumption-driven valuation methods (replacement cost approach), rather than production-driven (resource rent approach) (Bagstad et al., 2014). In essence, the former is inconsistent with the geographic boundaries of the GPI model, while the latter would focus on the costs and benefits within the boundaries. Talberth and Weisdorf (2017) point out that "tying each adjustment to its WTP [willingness to pay]/WTA [willingness to accept] foundation will help distinguish between ideal, second best, and invalid valuation approaches" (Talberth & Weisdorf, 2017, p. 3).

Substitutability. As an aggregate measure, GPI allows substitution across human-made and natural capital forms (weak sustainability). Proponents of strong sustainability argue that this is problematic. As Kubiszewski et al. (2013) point out, from a current welfare perspective, if the benefit increase in one item is equal to the benefit decrease in another, then one has compensated for the other. This is not the same as saying anything about the sustainability of welfare. Indeed, the GPI is not meant to be a measure of sustainability; it does not reflect the capacity of ecosystems to sustain welfare (Kubiszewski et al., 2013). As Lawn (2008) points out, indicators of sustainability are best left to measures of wealth or measures of natural capital; perhaps also complemented by comparisons between a nation's ecological footprint and biocapacity.

Weak theoretical foundations. Different economic theories have been used to justify GPI as an indicator of sustainable welfare (Hicks' maximum sustainable income) or an indicator of current welfare (Fisher's psychic income). Many GPI studies have conflated and mixed these two distinct capital theories, muddling the theory. Lawn's (2003) ex post theoretical exposition and subsequent work provides the main theoretical justification for GPI, basing GPI exclusively on Fisherian psychic income. Some have pointed out that GPI (and its predecessor ISEW) does not perfectly align with a purely Hicksian income nor Fisherian psychic income; more welfare items are included in GPI that require extending the two concepts (Van der Slycken & Bleys, 2020). Recent efforts (Talberth & Weisdorf, 2017; Van der Slycken, 2021; Van der Slycken & Bleys, 2020) seek to address some of the theoretical issues summarized by Bagstad et al. (2014) and others.

Limitations of a single-value, monetized indicator. Social theorists, feminist, ecological and other heterodox economists have highlighted the limitations of single-value, monetized indicators for measuring economic processes (e.g., Aitken, 2019; Waring, 2018). Marilyn Waring, for example, in her work on expanding the Systems of National Accounts (SNA) has questioned whether the expansion and correction of GDP indicators to include values of unpaid work for example, simply reinforces the notion that growth and GDP maximization should remain the central concerns of economic policy (Messac, 2018). For these reasons and more, Waring in her later work promoted a focus on time-use measures as a means of accounting for the costs and benefits of different policy measures (Waring, 2003, 2018) -- ideas which have generated contemporary calls for time policies (Lahat & Sened, 2020). Waring's and others' concerns about the limits of single-value, monetized indicators remain relevant to indicators such as GPI.

Limits to monetization. In the first case, as a system of accounting for costs and values in monetary terms, GPI may be limited in terms of what can be monetized and whether monetization is an appropriate reflection of the value placed by society on certain goods and services. Converting to monetary values does not square well with areas of economies or societies that are under-valued or for which monetary values assigned to this type of work or activity is a poor reflection of the activity's social value. This is particularly true for activities associated with people of color and women. Therefore, the GPI methodologies which rely on measures -- such as the average hourly wage of domestic/cleaning personnel -- are likely to grossly under-represent the true value of this labor/activity to the economy. In other words, this represents a "sizeable downward bias" on these activities "since the market wages being imputed to women homemakers are lowered both by discrimination and by the time and effort put into nonmarket work" (Folbre & Nelson, 2000, p. 129). Moreover, there are inherent limitations to the ability to monetize/commodify caring labor itself which depends on the quality of a relationship and does not respond to economies of scale (e.g., Hochschild, 2015). In addition, the value imputed to nonmarket activities is usually based on labor inputs alone (Hochschild, 2015), in contrast to more holistic measures of value. Conversely, activities with large positive externalities, such as participating in cultural activities, would likely be under-valued under a monetized value framing.

Costs versus benefits. In addition, some methodological concerns relate to GDP because whether something is considered a cost of economic activity or a benefit or asset depends on the way in which the issue is being considered. Moreover, boundaries between costs and benefits are infinitely more blurred and multi-dimensional in the social world than simplified accounting processes can convey. For example, one could account for the social cost of violence or conversely attempt to measure the positive value of health and personal wellbeing. Methodologically, datasets which rely on household surveys, rather than individual measures, are also problematic in that they overlook questions of intra-household inequality where it cannot be assumed that household resources are always evenly shared (e.g., Folbre, 2020).

Distribution and disaggregation. Finally, across the board GPI indicators are aggregates or averages which miss out on key distributional issues with regard to how the social costs of economic activities are distributed across different social groups, geographic areas and otherwise. Additionally, because indicators are not disaggregated by social factors, for example, inequalities related to race, gender, disability, socio-economic status, sexual identity and other factors are obscured in the composite GPI. The income inequality adjustment is a helpful but insufficient proxy for larger social inequalities embedded within the functioning of the economic system that GPI cannot, on its own, capture.

2.3. GPI in the U.S.

The GPI has been applied and adapted to many contexts, leading to methodological divergence, which undermines institutionalization.

GPIs (an umbrella term under which we count both GPI and ISEW studies) have been applied to dozens of nations, spanning the globe and development status. At the sub-national scale, provinces, counties, and cities in the US, Canada, Europe, Brazil, China, and likely elsewhere have calculated GPIs. While some of these studies have been published in peer reviewed journals, many remain in the gray literature (see Bleys and Whitby (2015) and Kenny et al. (2019), as well as Wikipedia (2021)).

State studies

State studies have diverged methodologically, leading to calls for standardization.

The first U.S. state study was an academic exercise for Vermont (Costanza et al., 2004); it closely followed the methods set out in Redefining Progress' 1999 annual update (Anielski & Rowe, 1999). The national methods were substantially updated again in 2007 (Talberth et al., 2007), and what has followed is a series of bifurcations and combinations of methods and datasets in subsequent state studies, as illustrated by Bagstad et al. (Bagstad et al., 2014). Efforts in Maryland (McGuire et al., 2012), Vermont (Erickson et al., 2013), and Hawai'i (Ostergaard-Klem & Oleson, 2014) combined methods from the early Vermont study and the 1999 national update. Each state adjusted the method in its own way to fit the local context; the recommendations from Hawai'i's study are outlined in the box below. Three states, Ohio (Bagstad & Shammin, 2012), Utah (Berik & Gaddis, 2011), and California (Brown & Lazarus, 2018), largely followed the 2007 national GPI methods, but each innovated the accounting methods for numerous components, and tapped into new and/or commercially available data sources that are more representative of the local scale. A recent study of GPI for all 50 states (Fox & Erickson, 2020), relied on the updated Vermont methods (Erickson et al., 2013).

Many authors have pointed out how these localized approaches have led to methodological advances, but also methodological discrepancies (Bagstad et al., 2014; Berik, 2020; Fox & Erickson, 2020). The trade-off of locally policy-relevant adaptations is inter-state comparability, a major objective of state GPIs (Berik, 2020; Ostergaard-Klem & Oleson, 2014). Moreover, many of the studies pose challenging questions related to the scope and objective of GPI, the answers to which directly affect what gets included and how those components are valued (Bagstad & Shammin, 2012). The consensus of the GPI research community is that a standardized methodology needs to be codified and agreed upon to increase the indicator's policy relevance.

RECOMMENDATIONS FROM HAWAIʻI ISLAND STYLE GPI STUDY (OSTERGAARD-KLEM & OLESON, 2014)

Economic

- Reconsider how to include PCE (downscaling from national data problematic), inequality (Gini inaccurate for small populations; disaggregate for subpopulations), costs of consumer durables, value of higher education (account for brain drain)
- Add cost of homelessness
- Factor in tourism and military (de facto population for both to reflect resource use)
- Misses risk of being reliant on a handful of sectors

Social

- Positive externalities from higher education may not be valid (double counting; graduates leave HI for jobs in US mainland)
- Value of housework should expand to encompass care economy
- Need to factor in frustration, not just value of time, to cost of commute
- Eliminate cost of family change, perhaps switch to benefits from ʻohana

Environmental

- Add reefs, fish, groundwater, soil
- Consider ecosystem quality (invasive species, degradation) in valuation
- Conduct localized valuation studies
- Drop air pollution, ozone depletion, cost of family change
- Reevaluate method of assigning damages from climate change to be consistent

Policy use of GPI in the states

Evidence of policy uptake of GPI is limited to-date.

Most GPI state-level studies have been one-off academic efforts; however, there are notable exceptions. Many analyses point to the need to build political constituencies to gain traction and embed GPI in the policy-making process (Berik, 2020; Fox & Erickson, 2020; Hayden & Wilson, 2018; Hoekstra, 2019; McGuire et al., 2012).

Maryland. Maryland's governor promoted GPI as a mechanism to evaluate policy, issuing an executive order in 2010 that funded a GPI effort within the state environmental agency (McGuire et al., 2012). Unfortunately, a change in governor resulted in a withdrawal of high level support. Despite finding little evidence of policy impact, Hayden and Wilson (2018) noted that the exercise in Maryland revealed a number of novel pathways and ideas for policy making that was more environmentally and socially progressive, which may indeed have long-term impacts.

Vermont. In 2012, Vermont legislatively mandated annual GPI updates (Erickson et al., 2013). A project was funded at the University of Vermont, and annual reports have been issued (Zencey, 2018). There seems to be little analysis to-date of the GPI's impact on policy.

Hawai'i. Hawai'i's GPI, initially focused on environmental components (Ostergaard-Klem et al., 2013) then extended to all components (Ostergaard-Klem & Oleson, 2014) was a product of a collaboration between the state's Environmental Council (housed within the Department of Health) and local universities, but it was not funded or operationalized. Current efforts to update Hawai'i's GPI in collaboration with the Department of Business, Economic Development, and Tourism (DBEDT), are promising.

2.4. GPI 2.0

The need for GPI 2.0

The GPI 2.0 effort centers around reaching consensus on GPI's definition, what purpose it serves, and its architecture.

GPI 2.0 is an effort to harmonize multiple different GPI approaches that have emerged in the course of the past two decades. GPI 2.0 was operationalized via a loose community of mainly academics, who held workshops and online discussions with an aim to build "consensus on how the metric is defined, what purposes it serves, and what basic architecture is thus justified for organizing its components" (Talberth & Weisdorf, 2017, p. 2). Work by numerous authors highlight some major issues standing in the way of harmonization and standardization that GPI 2.0 is working to address (Bagstad et al., 2014; Berik, 2020; Bleys & Whitby, 2015; Brown & Lazarus, 2018; Hoekstra, 2019; Talberth & Weisdorf, 2017; Van der Slycken, 2021; Van der Slycken & Bleys, 2020).

First, authors note that there is still disagreement about what GPI is trying to convey. Is GPI intended to be a sustainability indicator, an indicator of current welfare, or an ad hoc composite of information related to welfare and sustainability that is not well captured in standard product and income accounts (Talberth & Weisdorf, 2017)? The post hoc theory for GPI linked sustainable economic welfare to the level of current welfare, given past and present economic activity (Lawn, 2003). As neatly summarized by Van der Slycken and Bleys (2020) (Figure 2), articles have defined what GPI is and its purpose in subtly different ways.

Figure 2. Various ways authors define GPI (Van der Slycken & Bleys, 2020)

Lawn (2003)	"The sustainable economic welfare implied here is the welfare a nation enjoys at a *particular point in time* given the impact of past and present activities" (p. 106).
Posner and Costanza (2011)	"The GPI uses monetary valuation to assess the *impacts of economic growth* on sustainable welfare. GPI is an indicator that goes beyond measuring the quantity of economic activity to include details about quality, …" (p. 2, emphasis added).
Kubiszewski et al. (2013)	"…, the GPI is designed to measure the economic welfare generated by economic activity, essentially counting the *depreciation of community capital as an economic cost.*" (p. 57). "Economic activity, it should be recognized, is undertaken to generate a level of *economic welfare greater than what can be provided by natural capital* alone." (p. 58, emphasis added).
Talberth and Weisdorf (2017)	"The Genuine Progress Indicator is a monetary measure of economic welfare for a given population in a given year that accounts for *benefits and costs experienced* by that population in association with investment, production, trade, and consumption of goods and services" (p. 3, emphasis added).
Held et al. (2018)	"Taking the deficiencies of GDP as a starting point for consideration, those indices try to capture the *consequences of economic activities on current welfare* in a more comprehensive way, especially with regard to social and environmental issues. Therefore, monetized costs and benefits are aggregated across social, environmental and economic dimensions into one single indicator." (p. 392, emphasis added).

The definitional discord and lack of clarity in purpose can be attributed to different economic theories that have been used to justify GPI as an indicator of sustainable welfare (Hicks' sustainable income) or indicator of current welfare (Fisher's psychic income) (Van der Slycken & Bleys, 2020). Many studies have seemingly unwittingly combined these, leading to inconsistent methodological decisions about the metric's architecture, as these two concepts imply different time and spatial boundaries, with implications for how ecosystem costs, capital changes, and defensive expenditures are handled (Van der Slycken & Bleys, 2020).

As a result, we have seen broad divergence in GPI applications: what indicators, data, boundary choices, and how to value these components (Bagstad et al., 2014; Berik, 2020; Hoekstra, 2019). The lack of consistent data available across contexts to calculate GPI has further prompted divergence across studies (Kenny et al., 2019). A chorus of authors warn that the lack of standardization undermines the potential to inform policy and gain institutional support (Berik, 2020; Van der Slycken & Bleys, 2020).

State of the art

The GPI community is working towards improving and standardizing methods.

Drawing on insights from their review of the intellectual pathways that different state-level studies have taken, Bagstad et al. (2014) derived recommendations for a new standard. The authors point out four broad issues that need to be resolved across all indicators. Two are structural: (1) whether to value services or deduct their loss; and (2) whether national components (net capital investment and net foreign lending/borrowing) should be included. The other two are more routine decisions (that will nonetheless affect intercomparability of GPI studies): (3) whether to use local data or downscaled national data; and (4) how to reduce the potential for double counting. Furthermore, the authors stress the need to refine the indicator list; update the valuation approach; ensure public expenditures are not double counted; improve adjustments for inequality; value ecosystem quality; and use best available, commercial datasets. Two recent studies aim to operationalize these recommendations, while addressing many of the critiques described above: Talberth and Weisdorf (2017) and Van der Slycken and Bleys (2020).

The first, by Talberth and Weisdorf (2017), represents an effort to align GPI methods with a Fisher extended income perspective, presented as a utility function. Talberth and Weisdorf call for a purely Fisherian approach, valuing the costs and benefits of economic activity as experienced now by a given geographic population. This is the original theoretical grounding of GPI (Lawn, 2003), and the one that most GPI studies to-date have used. The GPI would therefore reflect welfare implications of past and current economic activity as they are currently experienced by a population in a given geographic area. Any capital change would not be included, as the effect of that change, e.g., less welfare generated in the future as a result of depleting the capital asset now would be accounted for at that future time. In essence, this approach focuses on the welfare impacts of past and current economic activity as experienced by a given geographic population in the present, with no reflection of capital drawdown, transboundary impacts, or implications for future generations.

Talberth and Weisdorf's (2017) methods differ from the former GPI approach in a number of key ways: market-based goods and services, services from essential capital, and disutilities from undesirable conditions, trends, and externalities.

<u>Market-based goods and services.</u> For market-based goods and services, the authors include public spending on goods and services that are not included in personal consumption expenditure data. They broaden the list of defensive and rehabilitative expenditures, and expand the list of household investment expenditures to investments with future payoffs. They change the method for the inequality adjustment to be based on diminishing marginal utility of income. They also suggest using alternatives to using personal consumption data from BEA's National Income and Product Accounts.

<u>Services from essential capital.</u> Stocks of human, social, built, and natural capital provide a stream of benefits from which all economic activity derives. Representing a relatively significant departure from some of the older GPI methods, Talberth and Weisdorf (2017, p. 5) propose to "measure public economic benefits above and beyond any facet captured in market-based transactions generated by investments in: (a) creating a highly educated, technically skilled and culturally diverse population (human capital); (b) goodwill and supportive relationships (social capital); (c) household, water, transportation, and other types of infrastructure (built capital), and (d) conserving and protecting native ecosystems (natural capital)". They note that "it is the utility generated by these investments that ought to be measured" and not the change in underlying capital stocks (p. 5). They use this logic to drop the national indicators from GPI of net capital investment and net foreign lending/borrowing. They also use this logic to credit ecosystem services from protected areas, but not all natural areas, to be consistent with GPI's scope, i.e., the costs and benefits of economic activity. Their logic is that the natural functions of the environment, while critical to wellbeing, are only a function of the economy if a result of conservation investment.

<u>Disutility associated with undesirable conditions, trends, and externalities.</u> Standard GPI studies include disutilities in the form of costs of crime, commuting, and pollution, the loss of leisure time, loss of farmland, wetlands, and forests, among others. Talberth and Weisdorf maintain all of these costs of economic activity, expanding the list to some items of interest to Hawai'i (homelessness, for instance). They do, however, significantly alter the valuation methods for some. Of particular interest is how the authors propose to deduct the cost of

natural capital depletion. Specifically, they deduct the net present value of the foregone stream of future benefits associated with the marginal loss of natural capital caused. They justify the inclusion of the loss of future ecosystem services by claiming that it represents “an undesirable condition or trend or a regrettable cost burden passed on to future generations” (p. A-11) that is a disutility for the current generation (e.g., guilt, anxiety) caused by them knowing that their current actions are destroying the environment for future generations. This expansion into the future has, however, been questioned by other researchers as the wellbeing impacts of those destructive behaviors will be recorded in future years, and needs further examination (Van der Slycken & Bleys, 2020).

Talberth and Weisdorf (2017) list 51 subindicators within the GPI calculation, grouped into 12 categories in 3 themes:

Market components

+ Household budget expenditures
- Defensive and regrettable expenditures (medical care, legal services, food and energy waste, pollution abatement, insurance, welfare neutral goods, security, family change)
- Household investments (consumer durable costs, household repair and maintenance, home improvement, higher and vocational education, savings/investment/retirement, charitable giving
- Costs of income inequality
+ Public provision of goods and services

Services from essential capital

+ Services from human capital (external benefits from higher education, manufacturing jobs, green jobs)
+ Services from social capital (value of leisure time, unpaid labor, internet services)
+ Services from build capital (value of transportation and water infrastructure, services from household capital)
+ Services from protected areas (marine, coastal, forests, etc.)

Environmental and social costs

- Depletion of natural capital (costs of land conversion, replacement costs of nonrenewable energy, replacement costs groundwater depletion, productivity losses due to soil erosion)
- Costs of pollution (criteria air pollutants, greenhouse gas emissions, noise pollution, water pollution, solid waste)
- Social costs of economic activity (costs of homelessness, underemployment, crime, commuting, vehicle accidents)

The second study, by Van der Slycken and Bleys (2020), notes that while the GPI 2.0 movement seems to be converging towards a method that complies with a Fisherian foundation, there is still room for interpreting the temporal and spatial boundaries of GPI, proposing two different approaches: (1) a narrow approach focused on the *Benefits and Costs Experienced*, and (2) a broader approach that reflects *Benefits and Costs of Economic Activity*. “Fisherization” is leading to “quite some confusion on what [ISEW/GPI] are actually measuring and to the use of a wide variety of (sometimes inconsistent) valuation methods” (Van der Slycken & Bleys, 2020, p. 7). They argue that Fisher inspires a narrow, *Benefits* *and costs experienced* approach, which roughly aligns with Talberth and Weisdorf (though Talberth and Weisdorf inconsistently go beyond the "here and now" scope for at least one component). Conversely, an approach they refer to as *Benefits and costs of economic activity*, is aligned with an extended Hicksian income and takes a geographically and temporally broader perspective. The lens is not on the welfare experienced by a geographic population, but rather on the ownership of the economic activity. This method includes net capital growth, accounts for damages caused to the future and the rest of the world from climate disruption, and considers the costs of resource depletion. The difference between the narrow (here and now) and broad (everywhere, anytime) approaches is detailed in Table 2.

Table 2. Components of narrow versus broad approach (Van der Slycken & Bleys, 2020)

"Narrow" Benefits and Costs Experienced	"Broad" Benefits and Costs of Economic Activity
Volunteer/unpaid labor Personal consumption Consumer durables Income inequality Non-defensive government expenditure Shadow economy Local pollution costs	Volunteer/unpaid labor Personal consumption Consumer durables Income inequality Non-defensive govt. expenditure Shadow economy Local pollution costs
Cost of extreme weather events	Climate damages globally from emissions
	Net physical capital growth Defensive expenditures Depletion of natural capital Non-renewable resource depletion
	Transboundary pollution Pollution/emissions embodied in trade Social costs embodied in trade
	Change in net international position

Components of Narrow vs. Broad (Van der Slycken & Bleys, 2020)

Van der Slycken and Bleys (2020) argue that measuring the benefits and costs of present economic activity using an extended Hicksian approach could achieve the same aims as previous GPI attempts that mix Fisher and Hicks income concepts (and thereby run into mismeasurement issues). The authors maintain that the broader perspective, which captures the costs and benefits of current economic activity wherever and whenever those costs and benefits are experienced, more accurately portrays the economy as embedded in the ecosystem, a key ecological-economic principle. Moreover, reflecting transboundary and temporal externalities, where populations shift the costs of economy to other people, places, and times, better represents the realities of an open economy, more accurately accounts for true progress, and reflects the equity principles. Finally, the authors point out that this approach increases the indicator's relevance for guiding sustainable and just economic policies.

Moving forward with GPI 2.0

The GPI 2.0 process is ongoing. More research is needed to further develop the theory and establish the compatibility between components and welfare (Talberth & Weisdorf, 2017; Van der Slycken, 2021; Van der Slycken & Bleys, 2020). Critics have asked whether ISEW/GPI (or any Beyond-GDP metrics) will ever gain footing in practical terms without a community consensus (Hoekstra, 2019). Many scholars have suggested limiting the components within the GPI/ISEW framework to “the big ticket items” (e.g., Bagstad et al., 2014; Brown & Lazarus, 2018; Fox & Erickson, 2018; Kenny et al., 2019) to facilitate standardization. This core set of components could then be complemented with locally specific ones to enhance policy relevancy. For the US, one recent study sought to standardize methods and data, though it used an admittedly outdated GPI 1.0 list of components and valuation methods (Fox & Erickson, 2018). In short, consensus on the methodology has yet to be solidified, but the main issues have been identified, and ongoing work is incrementally addressing them.

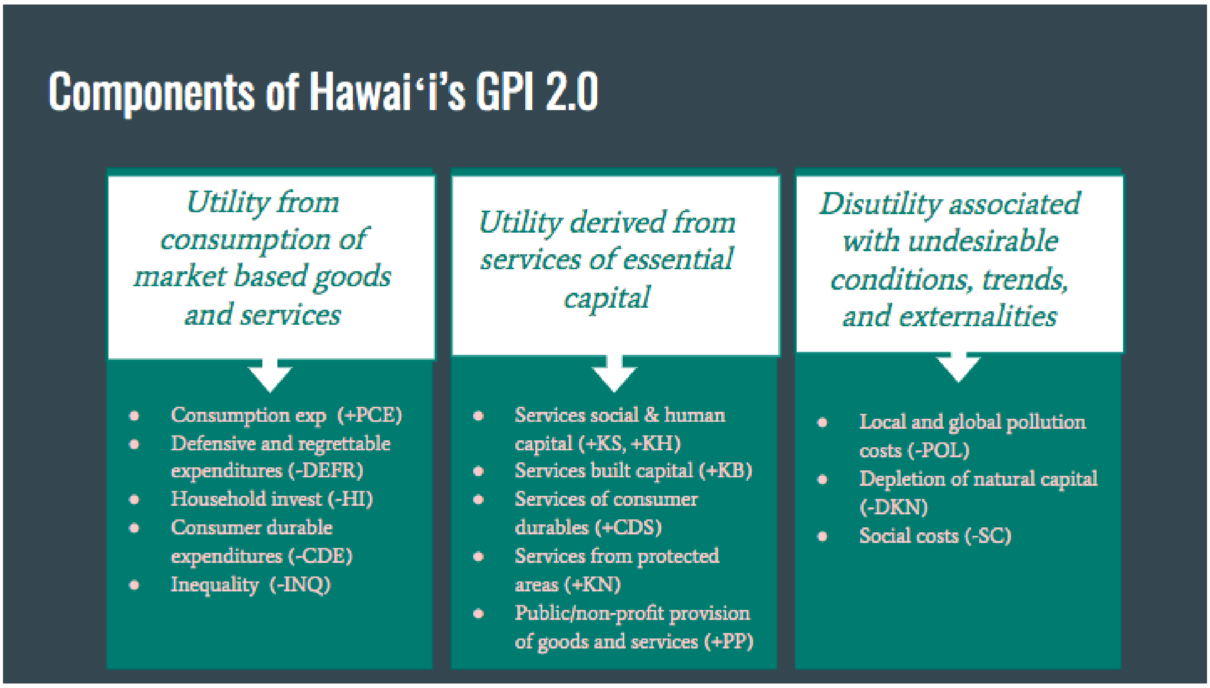
3. Hawai‘i’s GPI 2.0 Framework

The following provides an overview of 1) what Hawai‘i GPI 2.0 looks like; 2) how we built the structure; and 3) how we populated the structure.

3.1. What Hawai‘i’s GPI 2.0 looks like

For this most recent version, Hawai‘i GPI 2.0 closely follows the model set out by Talberth and Weissdorf (2017), a “here and now” approach to GPI which we decided to adopt largely as-is, but with some slight modifications. Figure 3 below portrays the components of Hawai‘i’s GPI 2.0 as three sets of indicators grouped conceptually by utility/disutility as GPI aims to more holistically capture the increases and decreases in utility that flow from economic activity. The calculation of GPI begins with personal consumption expenditures (PCE), the same base for calculating GDP. Moving through the series of indicators, GPI either adds or deducts from the base of PCE depending on whether the indicator registers a utility (increase) or disutility (decrease). For the sake of commensurability, all values use the same monetary unit (e.g. 2020 US$).

Figure 3. Components of GPI



Under the first component, the common characteristic among this group of indicators is that utility (either plus or minus) is generated through the consumption of market based goods and services. Here, consumption can be seen as protecting us from negative impacts of economic activity (defensive expenditures), or as welfare negative or neutral (regrettable expenditures), or as spending now which brings utility in the future (household investments or purchases of consumer durables). In addition, an inequality adjustment factor is included here to account for effects of diminishing marginal utility of income. This adjustment factor is a standard GPI mechanism based on the assumption that total overall welfare is more equitable when consumption distribution is more equitable (Talberth & Weissdorf, 2017).

The group of indicators under the second component collectively illustrate a wide range of services flowing from different types of capital (human/social, built, natural) that are essential to generating utility but not otherwise captured in PCE. Note that these indicators all represent a positive increase in utility derived from the flow of services.

The third component represents a set of indicators tracking disutility that stems from economic activity. Social costs can take the form of negative externalities of pollution, or decreased ecosystem services due to depletion of natural capital, or opportunity costs of time associated with commuting. In some cases, a cost to society that generates disutility (e.g. the material loss or physical costs of crime) actually contributes positively to PCE and therefore demands correction.

GPI Equation

GPI =

U(PCE_ADJ

+ PP + KS + KH + KB + CDS + KN

- POL - DKN - SC)

***where* PCE_ADJ =**
(PCE- DEFR - HI - CDE)*INQ

The three components are combined into an equation, following Talberth and Weissdorf (2017). Note that the adjustment to PCE for income inequality is made after subtracting out defensive and regrettable expenses, household investments, and consumer durable expenditures.

Looking broadly across the three components provides a more holistic and inclusive view of personal consumption spending which goes beyond GDP accounting conventions. When drilling deeper into the mechanics of how Hawai'i's GPI 2.0 works, the framework reveals 13 higher-level indicators that are further broken down into 37 subindicators (Figure 4). Definitions of these indicators and subindicators are listed in Table 3 to give a more detailed picture of what Hawai'i GPI 2.0 looks like.

Figure 4. Indicators within GPI

UTILITY FROM MARKET-BASED CONSUMPTIONS

1. Personal Consumption Expenditure (+PCE)

Household/individual annual consumption, the base for which GPI adjustments are made.

+PCE = Hawaii Personal Consumption Expenditures/CPI-U

2. Defensive and Regrettable Expenditures (-DEFR)

Welfare harmful or welfare neutral expenditures to be deducted from Personal Consumption Expenditure (PCE).

Food, alcohol and tobacco
(Welfare neutral goods)
Insurance and financial services
HH pollution abatement
(air, wastewater, solid waste)
Medical and legal services
Food waste
Energy waste
Alimony and child support
Lotteries

-DEFR = Costs of food & alcohol + tobacco + insurance & financial services + HH pollution abatement + medical & legal services + food waste + energy waste + alimony & child support

3. Household Investments (-HI)

Portions of consumption that are investments; to be deducted from Personal Consumption Expenditure (PCE).

Household repairs/maintenance and home improvement
Savings, investment, retirement
Charitable giving
Higher and vocational education

-HI = Household repairs/maintenance & home improvement + Savings, investment, & retirement + Charitable giving + Higher & vocational education

4. Consumer Durable Expenditures (-CDE)

Expenditure costs of consumer durables, including clothing, footwear, furnishings, household equipment, and vehicle purchases. To be deducted from Personal Consumption Expenditure (PCE).

Consumer durables
Appliances & furnishings
Vehicles

-CDE = Consumer Durables Expenditure in Hawaii* CPI-U

1.through 4. represent adjusted PCE

5. Cost of Income Inequality (-INQ)

Adjustment for the diminishing utility of income.

-INQ adjustment = (Adjusted PCE = PCE-DEFR-HI-CDE)*(1-DMUI) where a diminishing marginal utility of income ratio (DMUI) reduces the welfare from income above a certain threshold

6. Public and Non-Profit Provision of Goods and Services (+PP)

The annual value of non-defensive goods and services consumed by households/individuals but produced by public or non-profit entities.

Hawaii share of federal government non-defense spending, based on population
Hawaii share of State & Local based on population
Hawaii NPISH from BEA Regional Dataset

+PP = Hawaiii share of federal government non-defense based on population + Hawaii share of state & local based on population + Hawaii NPISH from BEA regional dataset

UTILITY DERIVED FROM SERVICES OF ESSENTIAL CAPITAL

7. Services from Social and Human Capital (+KS/KH)

Services from investments in human capital are accounted for by estimating social payoffs.

College Graduates
Manufacturing Jobs
Green Jobs
Unpaid Work
Leisure
Internet

+KS/KH = Value from College Graduates + Manufacturing Jobs + Green Jobs + Unpaid Work + Leisure + Internet

8. Services of Built Capital (+KB)

Services from investments in built capital are accounted for by estimating social payoffs. Net stocks are valued at a rate representing annual depreciation + interest.

Transportation/Highways & Streets
Water Infrastructure
Household Improvements

+KB = Value of transportation/highways & streets + water infrastructure + household improvements + services from consumer durables

9. Consumer Durables Services (+CDS)

Consumer Durables provide services beyond the initial year of purchase. Net stocks are valued at a rate representing annual depreciation + interest.

-CDE = Value of services from consumer durable stock

10. Services from Protected Areas (+KN)

Natural capital assets provide ecosystem services that enhance utility, some of which can be directly linked to economic activity and investments. Values by land cover derived from a global database.

+KN = total developed urban blue/green infrastructure + total cultivated land + total grassland + total tropical forest + total shrub/scrub + total palustrine wetlands + total wetlands/shore + total desert + total open water

DISUTILITY ASSOCIATED WITH UNDESIRABLE CONDITIONS, TRENDS, AND EXTERNALITIES

11. Local Pollution Costs (-POL)

Local pollution costs associated with economic activity are deducted because they are not welfare enhancing.

Air
Water
Noise
Solid waste
Greenhouse gas/Climate damages due to emissions

-POL = Costs for air + greenhouse gases + water + noise + solid waste

12. Depletion of Natural Capital (-DNK)

Depletion impacts current utility and affects future welfare).

Non-renewable energy
Groundwater
Soil erosion
Land conversion

-DNK = Costs of non-renewable energy + groundwater + soil erosion +land conversion

13. Social Costs (-SC)

Social costs of economic activity reduce overall welfare; some of these may already be accounted for in defensive expenditures.

Houselessness
Underemployment
Crime
Vehicle Crashes
Commuting

-SC = Costs of houselessness + underemployment + crime + vehicle crashes +commuting

Table 3. Indicator and subindicator descriptions

Indicator, *Subindicator*	**Description,** assumptions, and/or additional information
Personal Consumption Expenditure (+PCE)	Household and/or individual annual consumption, the base upon which GPI adjustments are made; reported by Bureau of Economic Analysis (BEA).
Defensive and Regrettable Expenditures (-DEFR)	Defensive expenditures serve to prevent or avoid unwanted effects of economic activity; regrettable expenses can either be welfare neutral (neither increasing nor decreasing utility) or harmful (decreasing utility). Both types of expenses are deducted from Personal Consumption Expenditure (PCE).
Food and alcohol	Welfare neutral; 25% of alcohol expenditures are deducted.
Tobacco	Welfare negative; 100% of tobacco expenditures are deducted.
Insurance and Financial Services	Insurance serves to defend utility from unbeneficial economic activity, so is not part of ultimate consumption. Financial services are intermediaries, not contributing to final consumption.
Household pollution abatement	Defensive expenditures by households to minimize negative impacts of economic activity on the environment. Includes equipment costs (catalytic converters to abate air pollution from personal vehicles) and household fees (sewer and solid waste) for wastewater treatment and trash collection and management.
Medical and legal services	Welfare neutral; medical care and legal services expenditures are deducted.
Food Waste	The cost of expenditures on food that is subsequently wasted using estimates of 25% of food is wasted at home and 19% in restaurants
Energy waste	Understood as the difference between current energy consumption and potential savings in energy consumption if more efficient best available technologies (BAT) are installed
Alimony and Child Support	Expenditures on alimony and child support are considered welfare neutral so are deducted.
Lotteries	Expenditures on lottery tickets are regrettable and not welfare enhancing so are deducted.
Household Investments (-HI)	Portions of consumption that are investments and thus should be removed from PCE now as their services will be accounted for later.
Household repairs/ maintenance and home improvement	Services from these investments made now will be accounted for in the services from built capital indicator (+KB) in the future.
Higher and Vocational Education	Education can be viewed both as consumption, in that it benefits one’s utility, as well as investment, in that it improves labor market outcomes; assumes that primary and secondary education are consumption, but higher/vocational education expenditures are investments in social capital (not to be confused with services from higher education flowing to college grads under the +KS indicator)

Savings, Investment, Retirement	These are investments by definition, providing services in the future, and should not be counted as consumption at present.
Charitable Giving	Expenditures on charitable giving are accounted for as investment in social capital rather than household consumption.
Consumer Durable Expenditures (-CDE)	Expenditure costs of consumer durables, such as clothing, footwear, furnishings, household equipment, and vehicle purchases, to be deducted from Personal Consumption Expenditures (PCE). Uses standard consumer durable figures reported by BEA.
Cost of Income Inequality (-INQ)	To account for diminishing marginal utility of income (DMUI), net consumption is adjusted for income inequality using the DMUI approach normalized at a sufficiency threshold. The equation *Adj = m*log(x/m)+m* is applied to household income above the median (below median is assumed linear DMUI), where household incomes are grouped into brackets of $5,000 (with $250,000 upper limit). The adjusted mean incomes of each bracket are multiplied by the number of taxpayer filings to establish utility-adjusted total income, which is then summed and divided by the unadjusted total income to create INQ.
Consumer Durable Services (+CDS)	Because Consumer Durables provide services beyond the initial year of purchase, consumer durable services are to be spread over an assumed eight years, and valued by multiplying the stock by a combination of a depreciation rate of 12.5% (assuming 100% depreciation divided by 8 years) and interest rate of 7.5% = 20%; uses BEA datasets for personal consumption expenditures on durable goods.
Public & Non-profit provision of goods and services (+PP)	The annual value of goods and services consumed by households/individuals but produced by Federal non-defense, state and local governments, or non-profit institutions serving households (NPISH).
Services from social/human capital (+KH)	Services from investments in human capital are accounted for by estimating a flow of social payoffs.
College Graduates	Higher education provides positive externalities to society to be accounted for; utilizes Census Data for share of population +>25yo with Bachelor's degrees and an estimated $16,000 per graduate for social payoff. Not to be confused with investments in higher and vocational education under the -HI indicator.
Manufacturing Jobs	Manufacturing jobs provide positive externalities to society to be accounted for; utilizes BLS local and state data on manufacturing jobs, and assigns an external benefit value of $10,000 per job year based on willingness to pay analyses from BLS.
Green Jobs	**N/A** – assumes green jobs provide positive externalities to society to be accounted for, but not applicable because BLS green jobs data are no longer reported.
Unpaid Work	Non-market unpaid work provides beneficial social services not accounted for in PCE or GDP. Includes non-market time from volunteering, housework, and caregiving from the American Time Use Survey (ATUS); data on hours spent on each non-market labor category is multiplied by the market cost of substitutable paid labor.
Leisure	Leisure hours enhance personal utility and are included as a welfare measurement; utilizes ATUS data on annual workday leisure hours and multiplies the hours by the opportunity cost (or post-tax median wage). Note: leisure is credited as a service, and to avoid double counting, lost leisure time should not be deducted later.
Internet	Captures the positive externalities and social benefits of internet access. Combines an estimate of the population 3 years old+ with home internet access with an estimated consumer surplus generated via internet access per user per year.
Services built capital (+KB)	While related additional non-consumption items are subtracted from PCE (e.g. -HI), the future services of these investments must then be accounted for

	here. Total services from built capital include the value of transportation/highways & streets + water infrastructure + household improvements
Transportation	Transportation stocks (streets and highways and transportation infrastructure for other other types of transportation) provide ongoing services beyond the initial cost to construct them, thus transportation infrastructure provides long-term social benefits to be spread over time; utilizes US NIPA account data on current net of depreciation stock values; less 25% of highways/streets used for commuting to avoid double counting; current stocks then multiplied by factor of 10% (combining a depreciation rate of 2.5% plus an average interest rate of 7.5%)
Water Infrastructure	Water infrastructure provides long-term social benefits to be spread over time; utilizes US NIPA account data on current net of depreciation stock values and the corresponding per capita values for local jurisdiction. Annual estimate of services found by multiplying current stocks by 10% (combining a 2.5% depreciation rate + 7.5% avg interest rate/time value of money)
Household Improvements	Accounting for the services of the household improvements that were deducted from -HI; stock year is calculated as the accumulation of the previous eight years of expenditures in the Household Investment indicator minus the standard 12.5% depreciation value. Expenditures in the current year are then added to the stock year calculation, and 20% of that final value is then added as value of annual services.
Services protected areas (+KN)	Natural capital provides ecosystem services that enhance utility beyond merely provisioning market goods and services that may be already accounted for in market consumption.
By land cover	Focuses on ecosystem services from protected areas as they represent a direct relation to conservation investment and services other than commercial products. Utilizes USGS National Land Cover Database (NLCD) and USGS National Gap Analysis Program’s protected area database to estimate a stock of the state’s protected areas managed for non-commercial use by land cover type. Stocks are then multiplied by ecosystem service estimates from similar land cover types.
Local pollution costs (-POL)	Costs related to the damages from local pollution resulting from economic activity are deducted because they are not welfare enhancing.
Air	Air pollution stemming from economic activities results in external costs through impacts on human health, damages to ecosystems, etc.; not to be confused with defensive expenditures to control air pollutants in order to avoid/prevent damage (in DEFR). Utilizes marginal damage estimates for criteria air pollutants to determine cost of emissions.
Greenhouse gas	Energy related CO_2 emissions contribute to climate change impacts; uses primary energy consumption for selected energy sources in physical units, converted to tons of CO_2 and multiplied by marginal damages per ton using the social cost of carbon; note this varies from the other categories in POL (local pollution) because SCC incorporates damages both outside of the geographical region and into the future.
Water	Water pollution is an externality of economic activity negatively affecting utility; uses estimates of impaired stream miles, converted to hectares equivalent, and multiplied by value to restore water quality. In lieu of impaired stream miles data, National Fish Habitat Risk Assessment data were used to identify high/very high risk ecosystems per different ecosystem type, converted to hectare equivalents using land cover maps, and multiplied by ecosystem service estimates for similar land cover types. Not to be confused with defensive expenditures to manage wastewater to avoid/prevent damage (in DEFR).
Noise	Loud and intrusive noises, especially in urban areas, are considered pollution by EPA and regulated under the Clean Air Act; noise pollution causes negative externalities such as lost productivity or sleep disruption. Uses vehicles as a proxy for noise pollution, by combining vehicle miles traveled data with marginal damage cost estimates from the Federal Highway Administration.
Solid waste	Municipal solid waste (MSW) is largely an outcome of economic activity and has associated external impacts; multiplies annual volume of local solid waste by an estimate of public external costs for solid waste per ton. Not to be confused with the defensive expenditures associated with managing solid waste to

	prevent damage (in DEFR).
Depletion of Natural Capital (-DKN)	Justified as the disutility generated by the depletion of different types of natural capital for those who are willing to pay to prevent their loss. Uses replacement costs using benefits transfer in the case of non-renewable energy, groundwater, and soil erosion; calculates net present value of changes from land conversion.
Non-renewable energy	Tracks depletion of non-renewable energy (NRE) resources and estimates the transition costs to replace NRE with renewable energy substitutes both inside and outside of the electric power sector; values replacement costs for transportation with biofuels, and electricity with solar and wind.
Groundwater	**N/A** - Accounted for as the replacement cost for groundwater depletion; not currently calculated due to incomplete data.
Soil erosion	Productivity losses can result due to soil erosion; accounted for as the replacement cost to restore soil lost due to soil erosion that typically results from economic activity and development.
Land conversion	Land conversions result from development and economic activity and impact ecosystems services provided by that land; valued as the marginal economic tradeoff of the land conversion activities. Calculates the NPV, over 50 years, at a 3% discount rate, using annual change in land cover and an ecosystem services value per unit of land cover type.
Social Costs (-SC)	Captures social costs that result from economic activity but reduce overall welfare, such as homeless/houselessness, underprovided labor hours, commuting time, or damage from crimes.
Houselessness	An undesirable social outcome largely due to housing market failures; multiplies an estimated cost of houselessness (shelters, public services, health care, etc.) per capita by number of houseless individuals.
Underemployment	Represents the utility lost when people want to work more but the labor market does not provide opportunities; uses estimates of annual unprovided hours per underemployed worker, underemployment rates, and wage rates.
Crime	Calculates the negative social and economic impacts of crime on individuals and households (e.g., trauma, fear, physical damage) using US Dept of Justice estimates of costs per type of crime; assumes that other costs, such as incarceration, are borne by the government.
Vehicle Crashes	Social costs from vehicle accidents can include property damage, lost household production, travel delay, etc. Standard economic measurement systems do not account for motor vehicle crashes as costs; in fact the side effects could be misconstrued as a positive economic gain.
Commuting	Estimates both the direct and indirect expenses of commuting. The direct, or out-of-pocket expenses relate to the money spent to operate a vehicle or for fare on a bus or other public transportation. The indirect costs are associated with loss of time while commuting, time that could have been spent on other, more enjoyable or productive activities.

3.2. Building the GPI structure: Two approaches, many options

To construct the GPI 2.0 framework for Hawaiʻi, we first set out to determine which approach to follow and what components to include. As part of that decision making process, we reviewed both past and current GPI literature, met with DBEDT and other stakeholders, and surveyed the current landscape of activity in Hawaiʻi related to sustainability indicators. To complement our broader outreach efforts, we engaged in our own internal evaluation of possible GPI frameworks, including that of our previous research on GPI “Island Style" (Ostergaard-Klem & Oleson, 2014). From a theoretical perspective, we noted that many past GPI studies have mixed economic theories, causing inconsistencies in methods and undermining theoretical rigor. We further analyzed two recent studies in particular (Talberth & Weissdorf, 2017; Van der Slycken & Bleys, 2020) that seek to clarify these inconsistencies and develop theoretically consistent methods. We spent significant time discussing the pros and cons of a narrow vs. broad approach to GPI and the relevant components, indicators, and subindicators of each. After careful consideration, we eventually chose to implement a narrow approach following Talberth and Weissdorf (2017). Our approach is further outlined and explained below.

Examined which GPI approach meets the goals set out by DBEDT.

Via an extensive review of the literature for both Beyond GDP and GPI complemented by meetings with DBEDT, we gained an understanding that an economic welfare indicator for the state should endeavor to assess whether:

- all citizens are thriving (current welfare, distribution, culture);
- the economy is at a sustainable scale (maintain capital stocks and environmental quality);
- we are good global citizens (transboundary externalities);
- we are good ancestors (intergenerational externalities)

In addition, the measure should:

- be comparable to GPI in other states
- be theoretically robust/based on literature

Surveyed the current landscape of sustainability indicators in Hawaiʻi.

We met with representatives and/or reviewed materials and literature from local community groups, researchers, and other stakeholders in the sustainability field in Hawaiʻi. Some of these organizations included: ʻĀina Aloha Economic Futures; The State of Hawaiʻi Office of Planning’s Statewide Sustainability Program; Hawaiʻi Data Collaborative; Aloha United Way ALICE Reports; Vibrant HI; Hawaiʻi Green Growth Aloha + Challenge Dashboard; and the UH Center of the Family Quality of Life in Hawaiʻi.

Reevaluated previous GPI work in Hawai‘i

In preparation for the Hawai‘i GPI 2.0 work, we reevaluated our earlier collaboration with the State of Hawai‘i Office of Environmental Quality Control (OEQC) and the State Environmental Council (EC) to showcase GPI in its 2012-2015 annual reports (see below in Figure 5). This platform made it possible to launch the inaugural version called GPI Island Style based on earlier GPI 1.0 models, and led to a peer-reviewed publication in 2014 (Ostergaard-Klem & Oleson, 2014). The GPI Island Style work created the foundation, both theoretically in terms of the model, and physically in terms of the series of Excel worksheets critical to calculating GPI, upon which the current Hawai‘i GPI 2.0 rests. See our comparison of the original Hawai‘i model with the newer GPI 2.0 models in Table A-1 in the Appendix A.

Figure 5. OEQC State of the Environment reports featuring GPI

Evaluated the pros and cons of a “narrow” versus a “broad” approach to GPI.

Two recent studies aim to operationalize these recommendations, while addressing many of the critiques described above. To implement GPI 2.0 in Hawai‘i, we went all the way back to the underlying theory behind GPI and weighed a number of options (not necessarily mutually exclusive) for choosing one theoretical basis over another. As shown in Table 4 below, we evaluated the options to use a “narrow” (Benefits and Costs Experienced/Fisherian) or a “broad” (Benefits and Costs of Economic Activity/Hicksian) approach. The table evaluates the strengths and weaknesses of each approach “as-is” (i.e., as found in the current literature) as well as the feasibility of adjusting to increase relevance to Hawai‘i by modifying the methods, and/or supplementing these with other relevant indicators.

Table 4. Factors we used to compare and evaluate a narrow versus a broad approach.

	"As is"	Strengths	Weaknesses	Modified	Supplemental indicators
Narrow (Fisher) Benefits and Costs Experienced	Talberth & Weisdorf (2017) **OR** Van der Slycken & Bleys (2020) narrow only	+Approach comparable to published studies; seems to be the way GPI 2.0 is going +Meets "all citizens thriving" goal +Most similar to GDP	-Leaves out transboundary, intergenerational aspects -Does not meet many of the goals set out -Could be misleading, as externalized costs ignored -Cannot be used for ex ante policy analysis	-Update Talberth & Weisdorf with insights from Van der Slycken & Bleys to make it more consistent with theory -Change framings and valuations for key social components (e.g., unpaid care and household work) -Change valuation for natural capital to be consistent with Fisher's theory (TBD)	-Add metrics of pollution relevant in HI
Broad (Hicks) Benefits and Costs of Economic Activity	Van der Slycken & Bleys (2020) broad	+More holistic survey of the costs of economic growth +Meets "good global citizens" and "good ancestors" goals by including transboundary and future costs +Useful for ex ante policy analysis	-Much broader/less comparable to GDP -New study, yet to be fully vetted by GPI2.0 community -May not be the path other GPI studies will go, which would undermine comparability		- Add natural capital relevant to Hawai'i (value of both services and depletion) -Expand list of services from social capital

In both cases, choosing either one could advance the GPI methodology and contribute to GPI 2.0 overall; however, a weakness of either choice could mean that our Hawaiʻi study is unique yet diverges from whatever methodology is adopted by the GPI community. Note that also in both cases, adding periphery indicators enhances local policy relevance, but could consequently be ignored in policy analysis under standardized GPI practices.

Determined which indicators should be used

For this, we evaluated individual indicators within the GPI for whether they:

- Represent a meaningful collection of components, representing a comprehensive set of what matters for Hawaiʻi
- Meet criteria for a good indicator
- Can be measured and valued with confidence
- Have data available

The results of this analysis are highlighted in Table 5 below. Most indicators have both established methods and available data (dark green). There are also some indicators where either methods or data are available but less formalized or complete than others (light green). In some cases, indicators either did not have sufficient data or methods were underdeveloped (orange). There are a handful of indicators where the method is problematic and/or data are unavailable (red). This analysis helped to justify our choice of Talberth and Weisdorf (2017) as a base model.

Table 5. Method confidence (M) and data availability (D) for each indicator in both Talberth & Weisdorf (2017) and Van der Slycken & Bleys (2020) approaches.

Indicator	*M*	*D*
Market-based goods and services		
Consumption Expenditure		
Public & Non-profit provision		
Defensive/Regrettable Expenditures		
Food and alcohol		
Tobacco and Narcotics		
Insurance and Financial Services		
Cost of Road Accidents		
HH pollution abatement		
Medical and legal services		
Food Waste		
Energy waste		
Alimony and Child Support		
Lotteries		
HH investments		
Household repairs/ maintenance and home improvement		
Higher and Vocational Education		
Savings, Investment, Retirement		
Charitable Giving		
Consumer Durable Expenditures		
Clothing & Footwear		
Appliances & Furnishings		
Vehicles		
Cost of Income Inequality		
Non-defensive Government Expenditures		
Net capital growth		

Indicator	*M*	*D*
Legend:		
Known method/data in hand		
Developing methods/data available		
Method/data uncertain		
Method/data problematic/unavailable		
Services from social/human capital		
College Graduates		
Manufacturing Jobs		
Green Jobs		
Unpaid Work		
Leisure		
Internet		
Cultural practices		
Services built capital		
Transportation		
Water Infrastructure		
Household Improvements		
Services of Consumer Durables		
Services protected areas		
Terrestrial and marine		
Cultural Sites		

Indicator	*M*	*D*
Local pollution costs		
Air		
Water		
Noise		
Solid waste		
Cost of extreme weather events		
Nitrogen		
Global environmental and social costs		
Climate damages due to emissions		
Climate damages due to trade		
Pollution damages due to trade		
Social costs embodied in trade		
Depletion of natural capital		
Non-renewable energy		
Groundwater		
Soil erosion		
Land/benthos conversion		
Fisheries		
Social costs		
Homelessness		
Underemployment		
Commuting		
Crime		
Family Breakdown		
Lost Leisure Time		
Vehicle Crashes		

3.3. Populating the structure: Worksheets, indicator formulae, and data

Once the GPI 2.0 structure was chosen (i.e., as-is implementation of Talberth and Weisdorf with slight modifications), we set out to verify the indicators, collect the best available data, and populate that model.

In Appendix A, Table A-1, we present a composite list of all indicators contained in the Talberth and Weisdorf (2017) and Van der Slycken and Bleys (2020) proposed GPI 2.0 approaches, with detailed descriptions, and contrast their valuation approaches to our original Hawai‘i study, which followed the older GPI methodology. Data availability was one of the most important criteria to determine which indicators were “in or out."

Data availability tends to constrain the ability to calculate GPI at sub-national scales. Some studies have gotten around this by downscaling national level data, but this is problematic, particularly for Hawai‘i, where, for instance, the cost of living is high so the downscaling adjustment could underestimate true expenditures (Ostergaard-Klem & Oleson, 2014). More recent studies have relied on commercially available data that is now more readily available at the local level, but limited to just a single year (e.g. Esri consumer spending data).

We followed Talberth and Weisdorf (2017) closely, with some minor adjustments to their GPI 2.0 pilot accounts. We made some exceptions in terms of localized information and in some cases clarified calculations. For some indicators, we lacked the data that exist for the contiguous US, and needed to improvise. For instance, Hawai‘i does not report regularly on stream impairment; therefore, we used a USGS risk analysis on fish habitat to estimate the miles of impaired streams.

Paralleling Bagstad et al. and Talberth and Weisdorf, we considered using ESRI county-level personal consumption data to estimate defensive and regrettable expenditures and household investment. However, we learned that ESRI only sells data for the current year; in our case, that year was 2020. We were uncomfortable applying a ratio of expenditure to personal consumption from 2020 to all previous years. First of all, due to COVID-19, any data from 2020 will be unusual and not likely valid for other years. Secondly, BEA has annual data at the statewide scale, which is the scale of our study, so the advantages of ESRI’s county data were not relevant.

For the indicators which we could not include in the overall GPI calculation (i.e., green jobs, groundwater) due to missing data, we have provided the framework and potential structure which could be employed once the proper data are identified or generated. The lack of data for these indicators highlights the need to collect better information on these specific topics.

For those indicators for which we had limited data points (water quality, land conversion, etc.) we used the data we have as estimates for all years 2000-2020. For instance, for water quality, we had a fish habitat risk assessment for 2010 and 2015; currently, we only use the 2015 maps to estimate stream impairment. For all the indicators that rely on land cover, we used NOAA‘s CCAP land cover dataset, which is released every ~5 years. We used both

2005 and 2010 CCAP land cover in the natural capital calculations, often using these two years to estimate a linear relationship that we extrapolated across the entire study period.

For all of the indicators that need valuations of ecosystem services, we rely on the estimates from the Ecosystem Services Valuation Database (ESVD). We crosswalked CCAP land covers with ecosystems from ESVD, and used global average per hectare values due to the lack of localized valuation estimates. The trade-off of using global average values is that the value obviously does not reflect the local situation.

4. Hawai‘i’s GPI Indicator Estimates (2000 - 2020)

This section presents figures illustrating trends across the study period (2000-2020) for each indicator within GPI. We note key take-aways for each figure in bullet points. All monetary values are in 2020 US dollars.

Table 6. Average performance of key indicators (2000-2020)

Variable	Average (2000-2020)	Variable	Average (2000-2020)
GPI (Billion US$ 2020)	52.62	GDP (Billion US$ 2020)	79.31
Average annual change GPI (%/year)	1.53	Average annual change GDP (%/year)	1.55
Per capita GPI (Thousand US$ 2020)	38.94	Per capita GDP (Thousand US$ 2020)	58.71
Average annual change per capita GPI (%/year)	0.78	Average annual change per capita GDP (%/year)	0.79

Key points table 6:

- **GPI was well below GDP every year** for the study period. This is explained in part by GPI’s adjustments for non-welfare enhancing private and public expenditures and investments (personal consumption expenditures on alcohol, tobacco, protective measures; military expenditures) and external costs of economic activity (loss of natural capital, social costs, pollution). Net exports, a component of GDP, is also not included in GPI.
- Growth in both GPI and GPI per capita were above growth in GDP and GDP per capita based on averages over the 20 years.
- Population increased by nearly 14% from 2000-2020. Population growth rates between 2000-2020 averaged <1% per year, with the past four years experiencing slightly negative growth.

Figure 6. Total GPI vs. GDP (total and change)

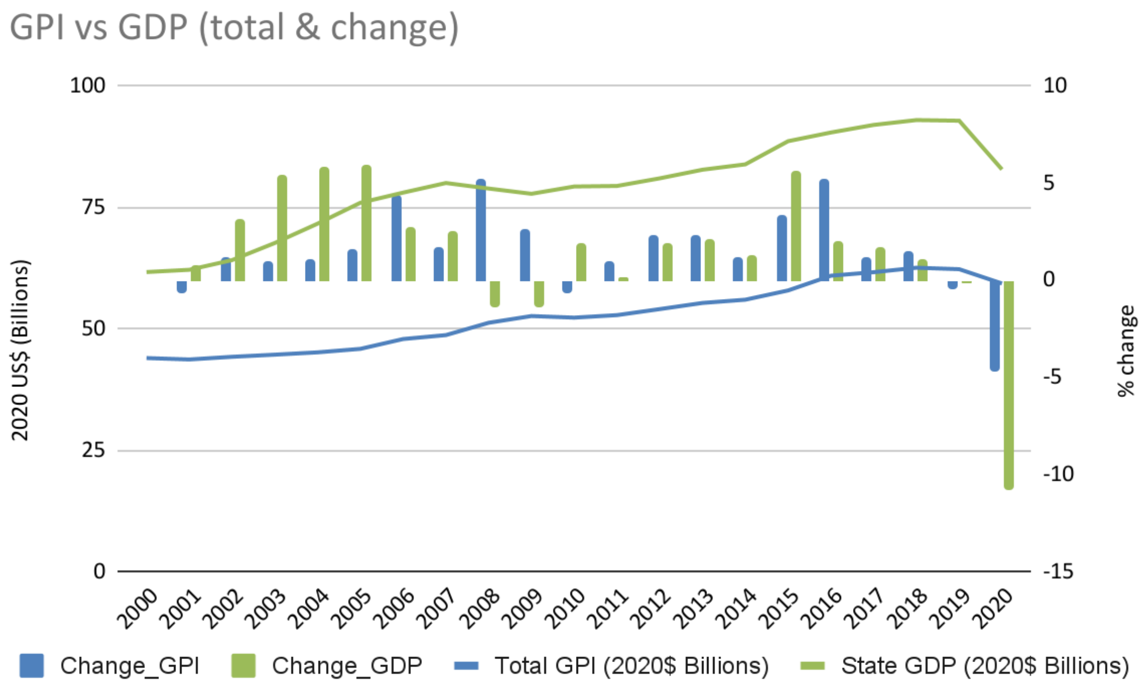


Figure 6 take-aways:

- The state's GPI was consistently lower than the state GDP (63.5% on average).
- GDP growth was higher than GPI growth from 2000-2004, however, GPI growth exceeded GDP growth in many years from 2005-2020.
- The state's GPI generally trended upwards over the study period (2000-2020), with 2010 and 2019-2020 exhibiting annual declines. GPI continued to climb while GDP dropped during the 2008-2009 financial crisis, though GPI decreased slightly in 2010. GPI also fell less than GDP during the 2020 COVID-19 pandemic crisis.
- There are a few periods where GPI and GDP digress: 2000-2004, 2008-2010, and 2020. Multiple factors could be leading to each of these individual discrepancies. Some insight into what is driving them can be gleaned from examining the component parts of GPI, although each period is unique and there is no obvious single explanation.

Figure 7. GPI, per capita GPI, GDP, per capita GDP (total and change)

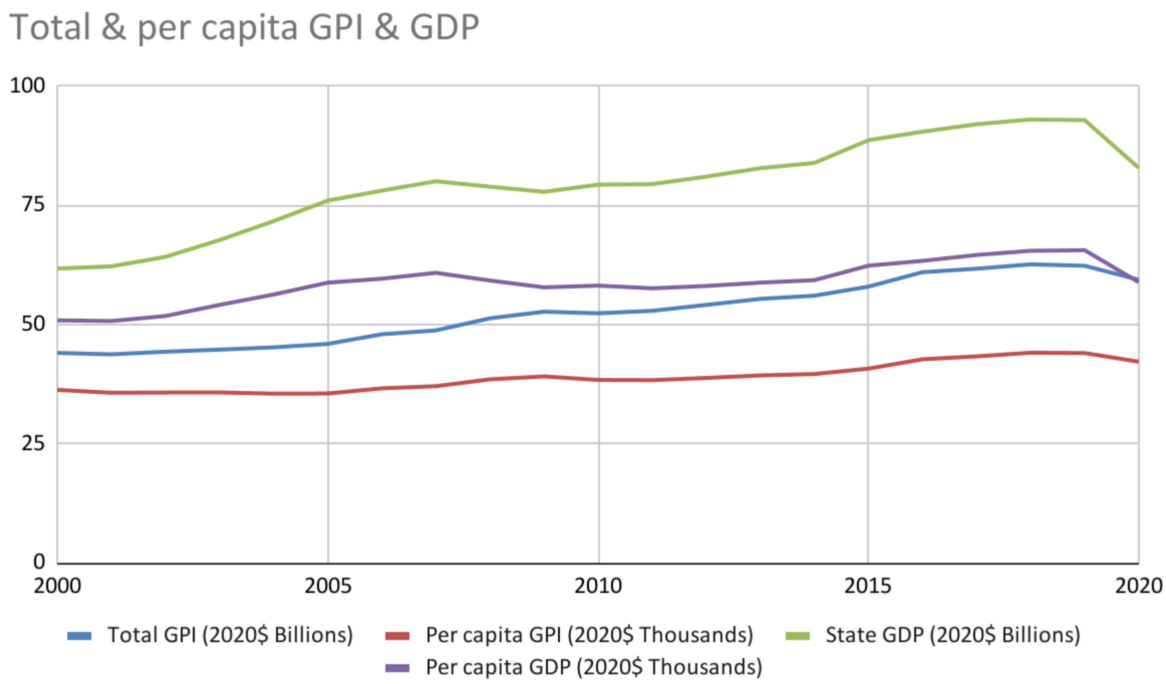


Figure 7 take-aways:

- This figure adjusts for population change. GDP per capita represents the per capita output of the economy. GPI per capita gives an indication of the average welfare across society.
- GDP grew 34% and GPI grew 35% over the 20-year period. Per capita GDP grew 16%, and per capita GPI 16% over that period.

Figure 8. GPI indicators as a stacked bar graph

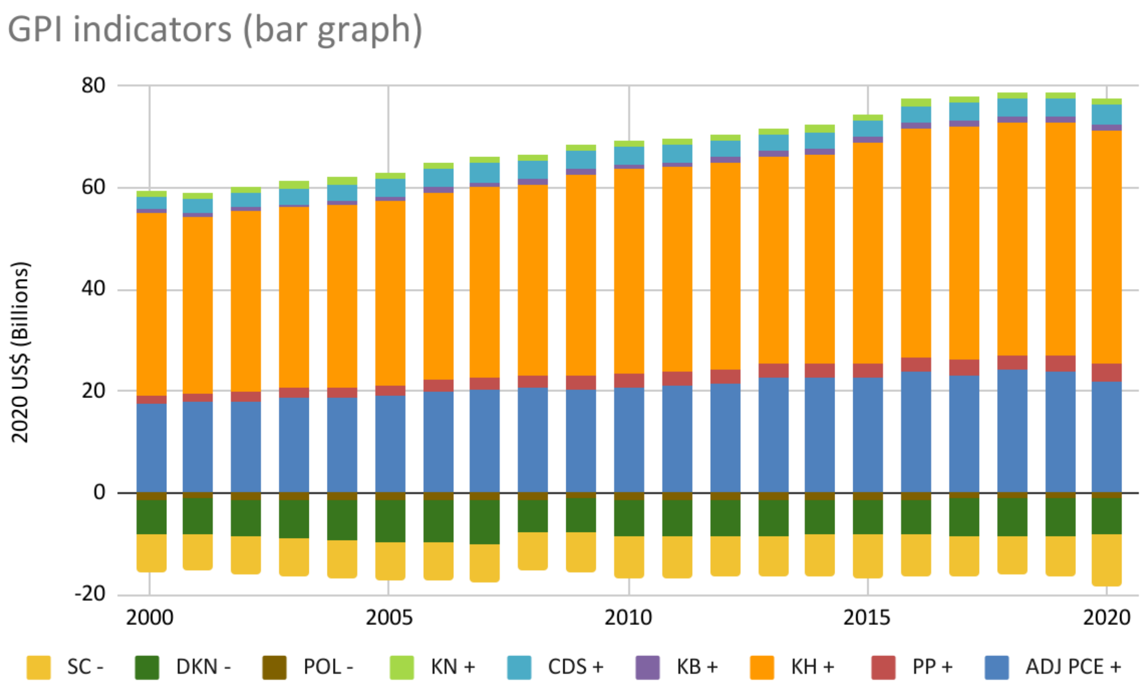


Figure 8 take-aways:

- The largest portions of GPI were the human capital (KH+) and the adjusted personal consumption (ADJ PCE+) indicators. Human capital includes College Graduates, Manufacturing Jobs, Unpaid Work, Leisure and Internets. Green jobs was not included due to a lack of data. Adjusted personal consumption was calculated as personal consumption minus: defensive and regrettable expenditures, household investment, and consumer durable expenditures, the result of which was then adjusted for income inequality in society.
- Deductions for loss of social costs (SC-) overtook natural capital (DKN-) in 2008 as the largest deduction.

Figure 9. GPI indicators as line graph

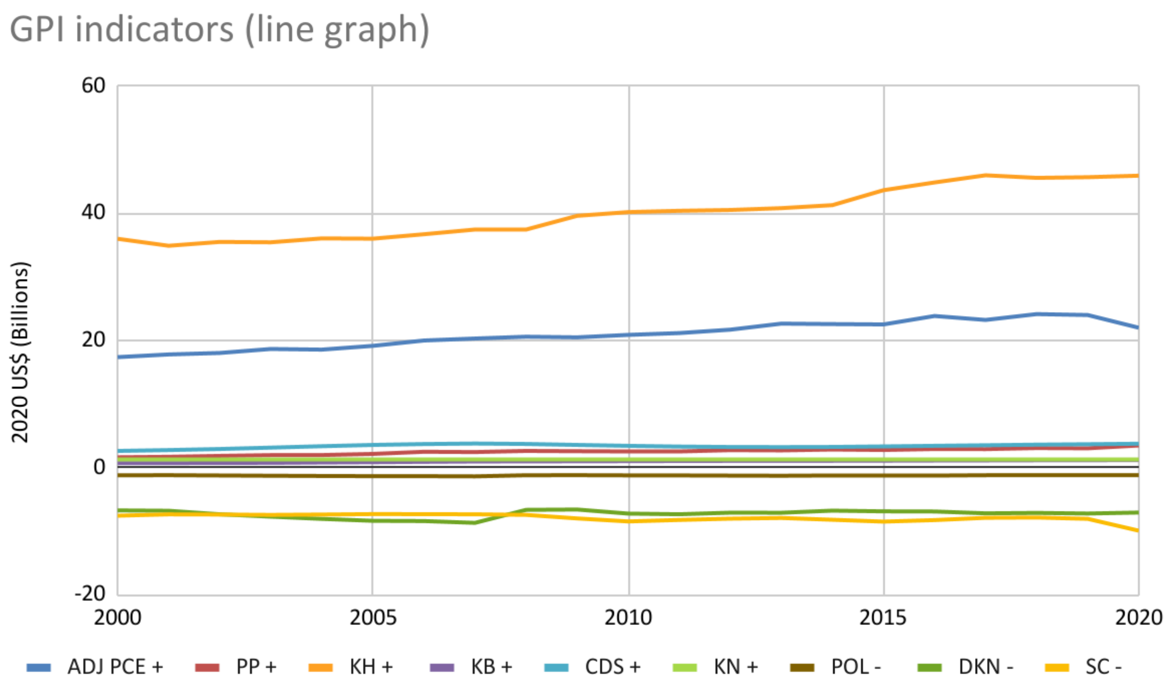


Figure 9 take-aways:

- This figure presents the same data as the previous figure in a different format. In this format it is easier to see trends in each individual indicator.
- Human capital (+KH) and adjusted personal consumption (ADJ PCE+) generally trended upwards.
- Costs to social capital (-SC) increased over the period, indicating worsening social conditions.
- The kink in the costs from depletion of natural capital (-DKN) in 2008 was driven by the sub-component energy consumption, specifically a drop in consumption of natural gas and petroleum. A sharp decrease (from .2T BTU to .1T BTU) in natural gas consumption led to corresponding drop in natural gas consumed outside the electric power sector (no natural gas is used in Hawai‘i’s electric power sector). Note also the drop in petroleum consumption outside the electric power sector (28% decrease in BTU). At the same time, coal use peaked in 2008.

Figure 10. Adjusted PCE

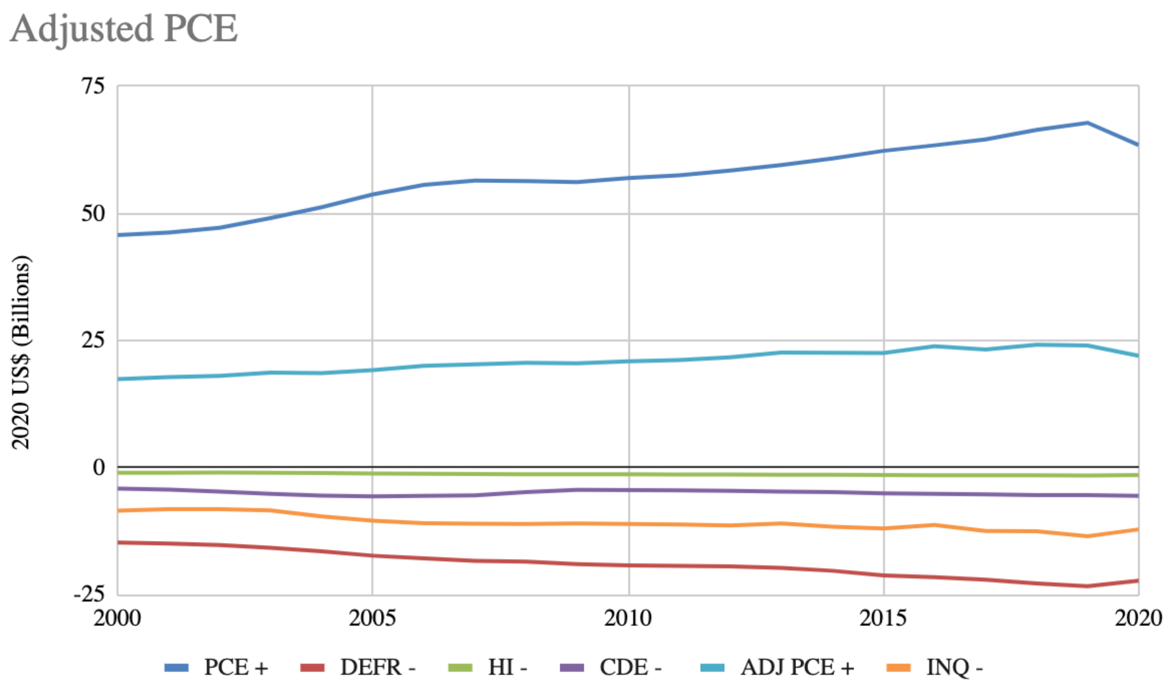


FIgure 10 key take-aways:

- PCE is adjusted by five things (becoming ADJ PCE+): defensive and regrettable expenditures (DEFR), household investment (HI), expenditures on consumer durables (CDE) and income inequality (INQ).
- Growth in ADJ PCE was driven by PCE. DEFR affected declines of Adjusted PCE the most, followed by income inequality then investments in CDE.

Figure 11. Adjusted PCE, without PCE

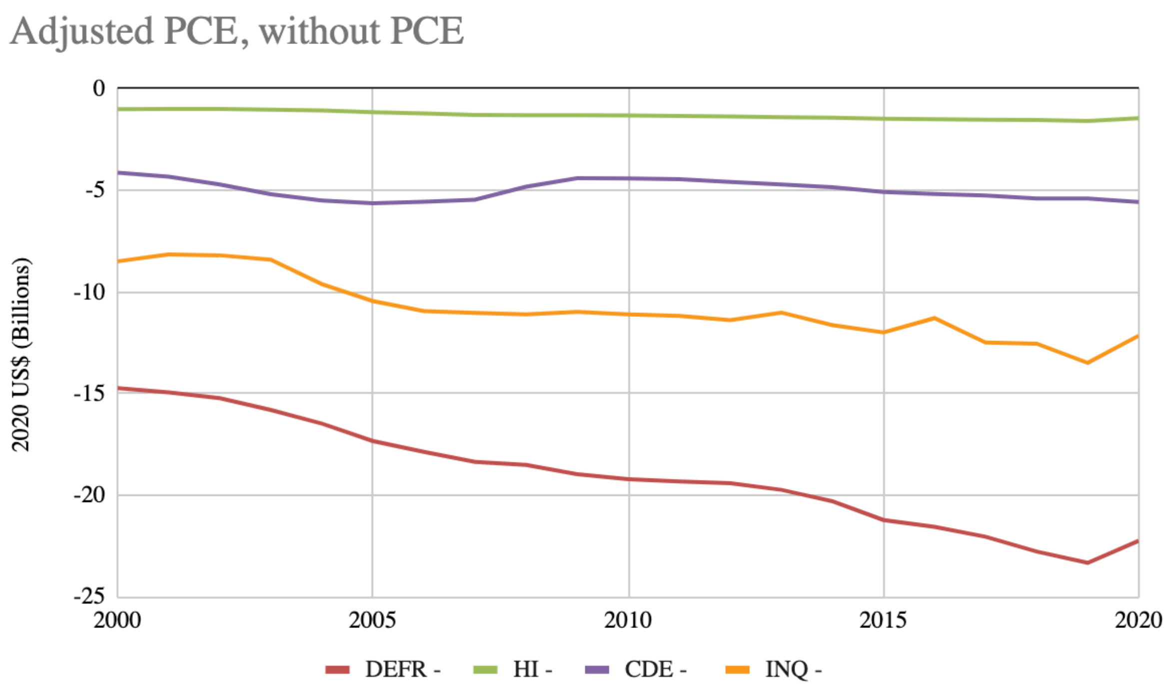


Figure 11 key take-aways:

- This figure presents the same data as the previous figure, focusing on the adjustments to PCE, to highlight individual trends.
- Defensive and regrettable expenditures steadily increased over the study period (undesirable), with a slight decline in 2020, reflecting a reduction in “classic” non-welfare enhancing expenditures during COVID-19 crisis. (Expenditures on personal protective equipment and other similar expenses people incurred due to COVID may not be fully captured in the current BEA line items that constitute the DEFR.)
- An increasing trend in expenditures for consumer durables early in the study period was interrupted by the 2009-2010 financial crisis.
- While the ratio of adjusted income to unadjusted income stayed relatively constant over the study period (average 66%; see Figure 23), the magnitude of the deduction from the income inequality adjustment grew over time due to PCE growth.

Figure 12. Defensive and regrettable expenditures subindicators

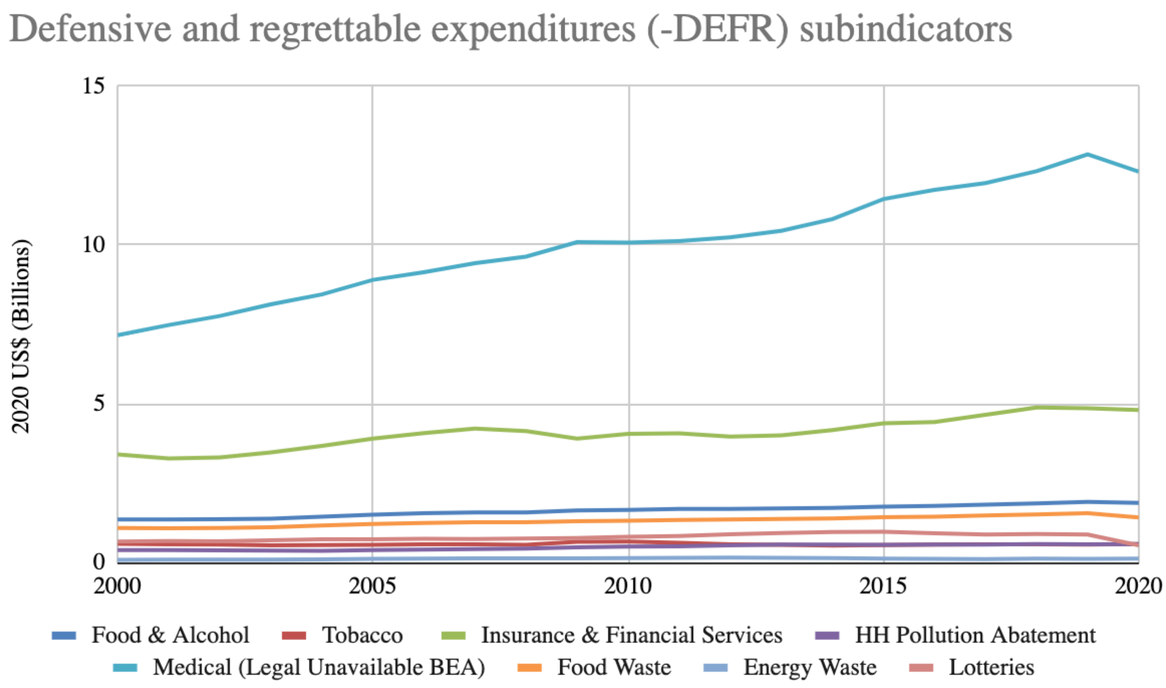


Figure 12 key take-aways:

- DEFR includes eight subindicators related to non-welfare enhancing personal consumption (food and alcohol, tobacco, insurance and financial services, household pollution abatement, medical expenses, food waste, energy waste, and lotteries).
- DEFR was driven primarily by Medical expenses, which increased substantially over the study period. Insurance and financial services were another key contributor to DEFR.

Figure 13. Household investment subindicators

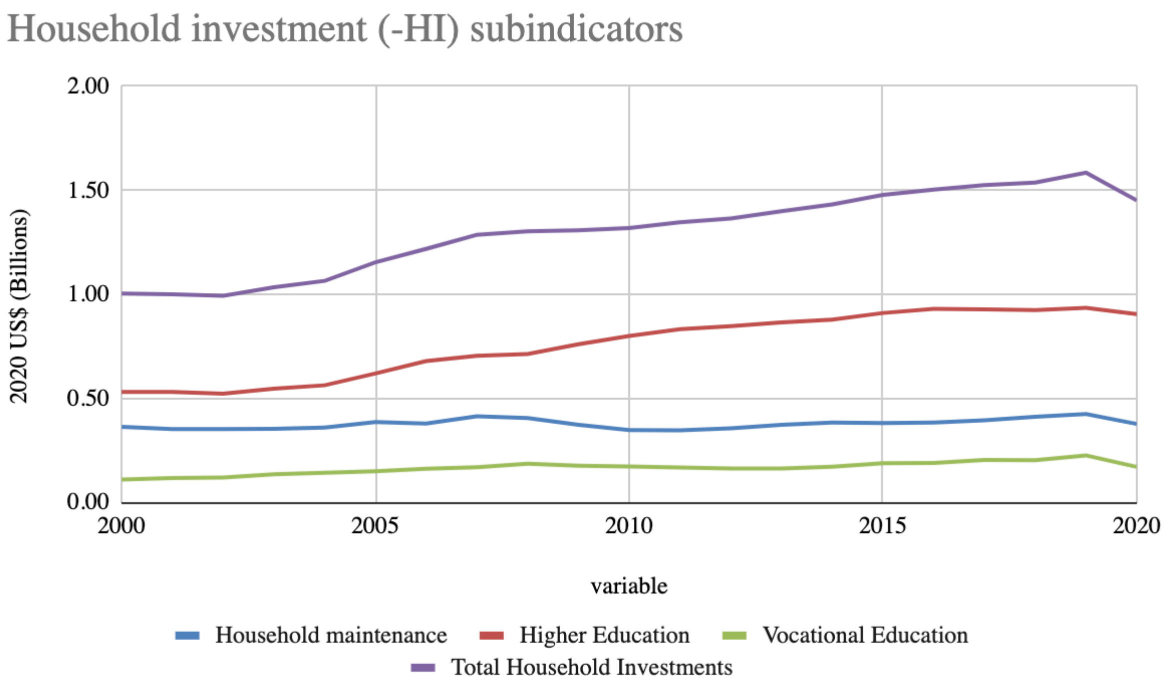


Figure 13 key take-aways:

- Household investment (+HI), one of the adjustments to PCE, includes three subindicators: household maintenance, expenditures on higher education, and expenditures on vocational education.
- Higher education constituted the largest driver, and expenditures increased over the period.

Figure 14. Services from human capital subindicators

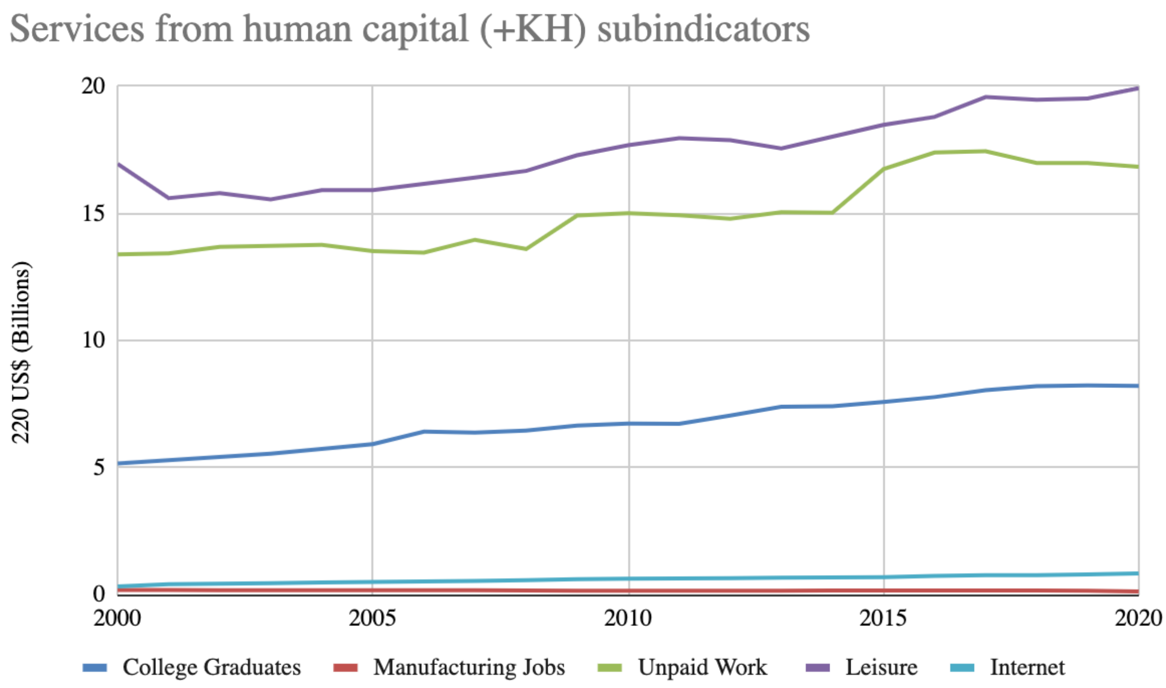


Figure 14 key take-aways:

- This indicator has five subindicators: college graduates, manufacturing jobs, unpaid work, leisure, and internet.
- Services from human capital (KH+) were the main contributor to GPI overall (see Figure 9).
- The indicator comprises the "pay off" of investments in people and social institutions, and other "social" contributions to wellbeing not captured by the market economy. KH includes five components: college graduates, manufacturing jobs, unpaid work, leisure, and internet.
- The upward trend in services of Human Capital is mostly driven by Leisure, Unpaid Work, and College Graduates. All but manufacturing jobs increased over the period.

Figure 15. Pollution subindicators

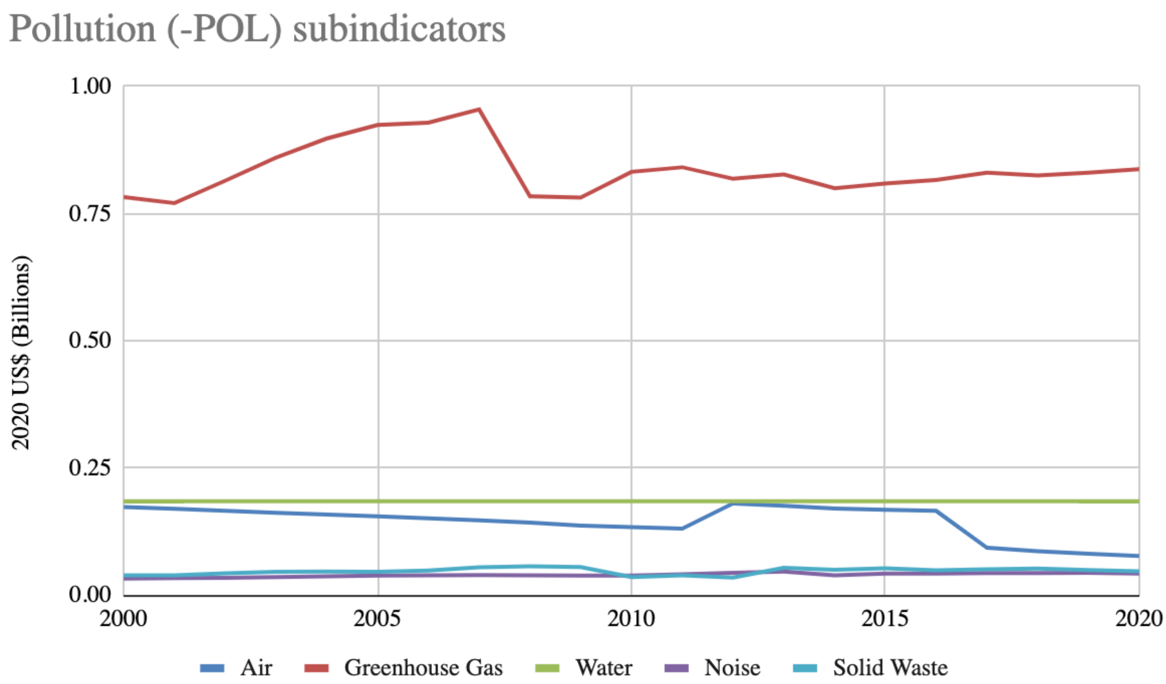


Figure 15 key take-aways:

- This indicator comprises five subindicators (air pollution, water pollution, noise pollution, solid waste pollution, and emissions of greenhouse gasses).
- The global cost of greenhouse gas emissions represents the highest pollution cost. The dip in 2008 is due to a reduction in statewide natural gas and petroleum consumption.
- Notably, the greenhouse gas emissions subindicator accounts for greenhouse gas emissions in Hawaiʻi, based on primary energy consumption and fuel type, without accounting for trade or air transportation. (Also note that, by calculating the damages caused from emissions, this is the single indicator in Talberth and Weisdorf's method that diverges from the "here and now" Fisherian constraint. Other studies examined the local damages suffered from locally-experienced climate change impacts, rather than the damages caused through emissions.)
- Data to estimate the cost of water pollution were only available for one year, hence the uniform estimate.

Figure 16. Services from built capital subindicators

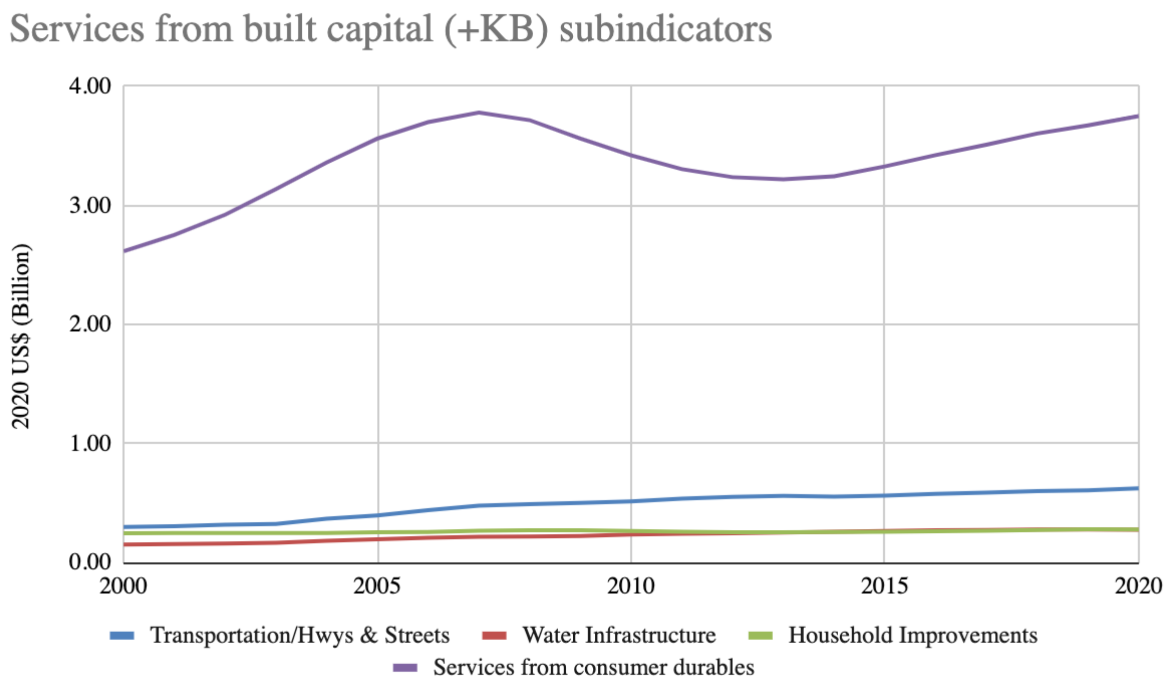


Figure 16 key take-aways:

- Services of built capital is made up of four subindicators: transportation and highways and streets, water infrastructure, household improvements, and services from consumer durable expenditures.
- Growth in Services of Built Capital (+KB) is mostly driven by services from consumer durables (+CDS) and Transportation. CDS represents the services from the past 8 years of investments in consumer durables. The dip in 2007-2012 reflects the effects of the financial crisis.
- Services from transportation and highways and water infrastructure continued to rise over the time period; both saw a relatively big bump in 2004 and then again in 2006, although the indicator for services from streets and highways grew at a faster rate.

Figure 17. Social cost subindicators

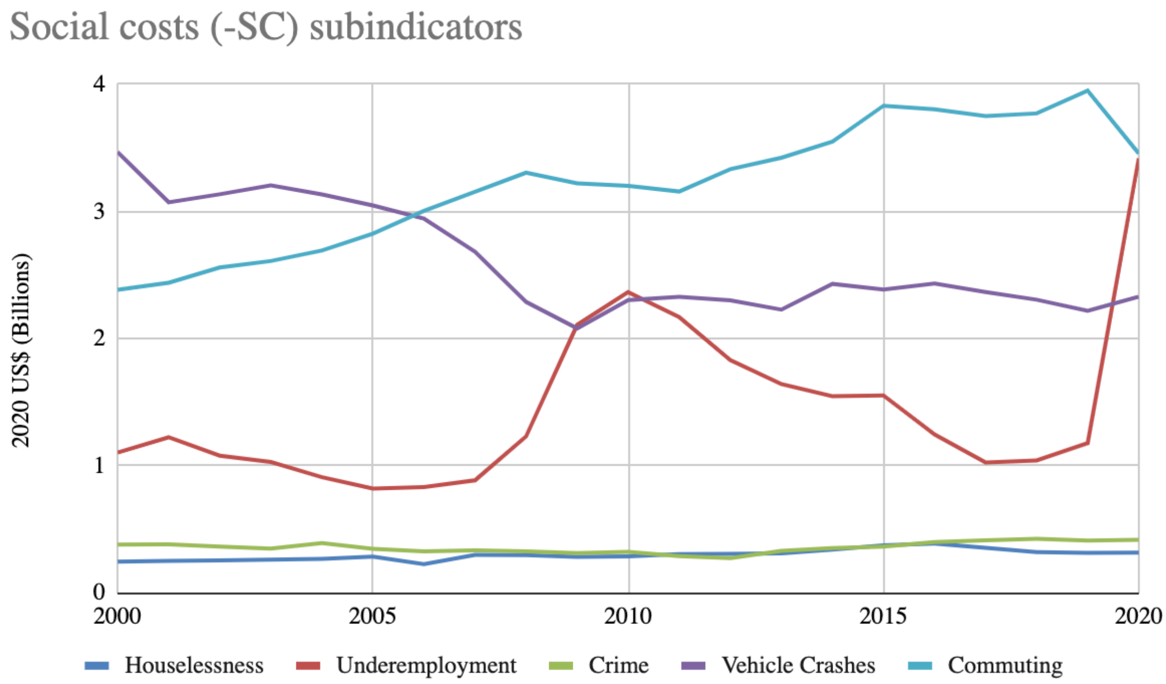


Figure 17 key take-aways:

- Social costs comprise costs of houselessness, underemployment, crime, vehicle crashes, and costs of commuting.
- Cost of commuting represents the highest social cost in all years post-2006. Commuting costs have risen as average number of commuters and travel times have risen over the years; expect to see impacts from 2020 and change in commuting patterns.
- High underemployment costs explain the increases in social cost in 2010 and again in 2020.

Figure 18. Depletion of natural capital subindicators

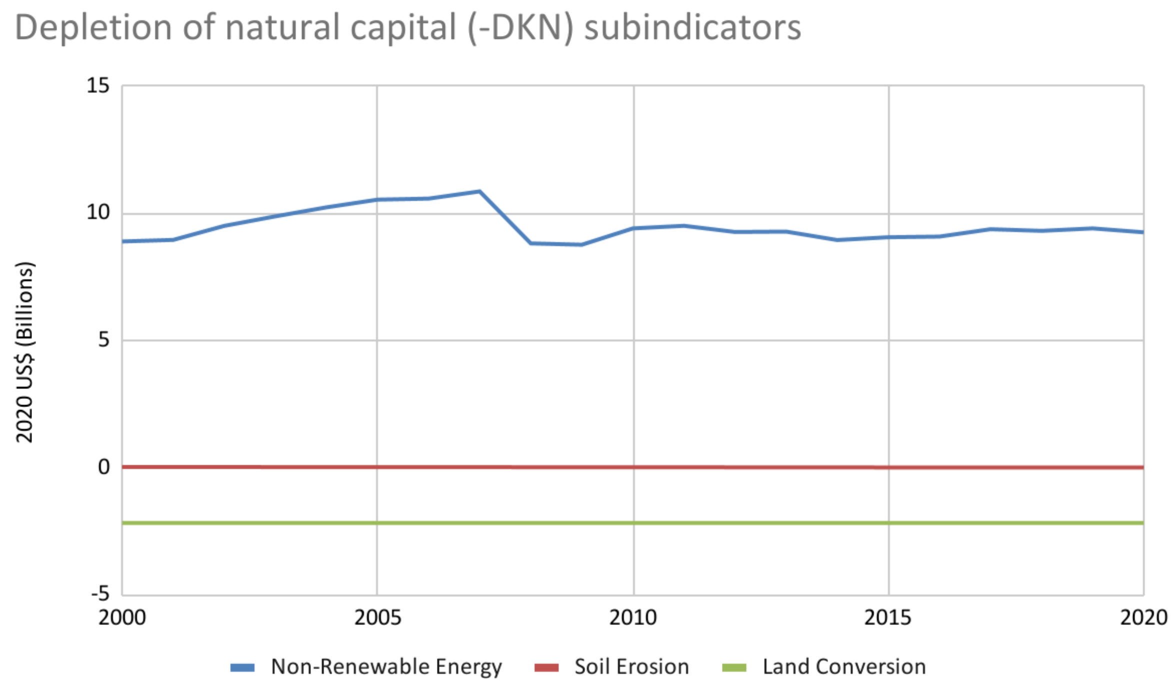


Figure 18 key take-aways:

- The subindicators falling under this category include the depletion of different types of natural capital: use of non-renewables sources of energy; erosion of soil; and conversion of land.
- Non-renewable energy consumption (natural gas and petroleum) represents the costliest portion of depletion of natural capital. It declined sharply in 2008.
- Land conversion was a net positive at ~$2.2 billion per year (2020 US$). This counterintuitive result reflects gains in valuable urban areas and grasslands that compensate for losses in forest, croplands, pastureland, and shrubland. Notably, these results are extremely sensitive to the value per hectare applied, i.e., the estimated value for urban areas ($2.7 million/hectare) is far greater than forests ($185,136/hectare).
- The total cost of land conversion is the same across all years due to data limitations. Land conversion extrapolates a trend from land cover data in 2005 and 2010 for nine different land cover types. The average annual change in land cover between 2005-2010 is applied to all years.
- Soil erosion focuses on cultivated cropland, which declined from 137 thousand acres in 2000 to just 13 thousand acres in 2020. Cost of soil erosion did decline from 0.03 billion in 2000 to nearly nothing in 2020, but the scale on the figure is too small to detect the difference.

Figure 19. Services from protected areas subindicators

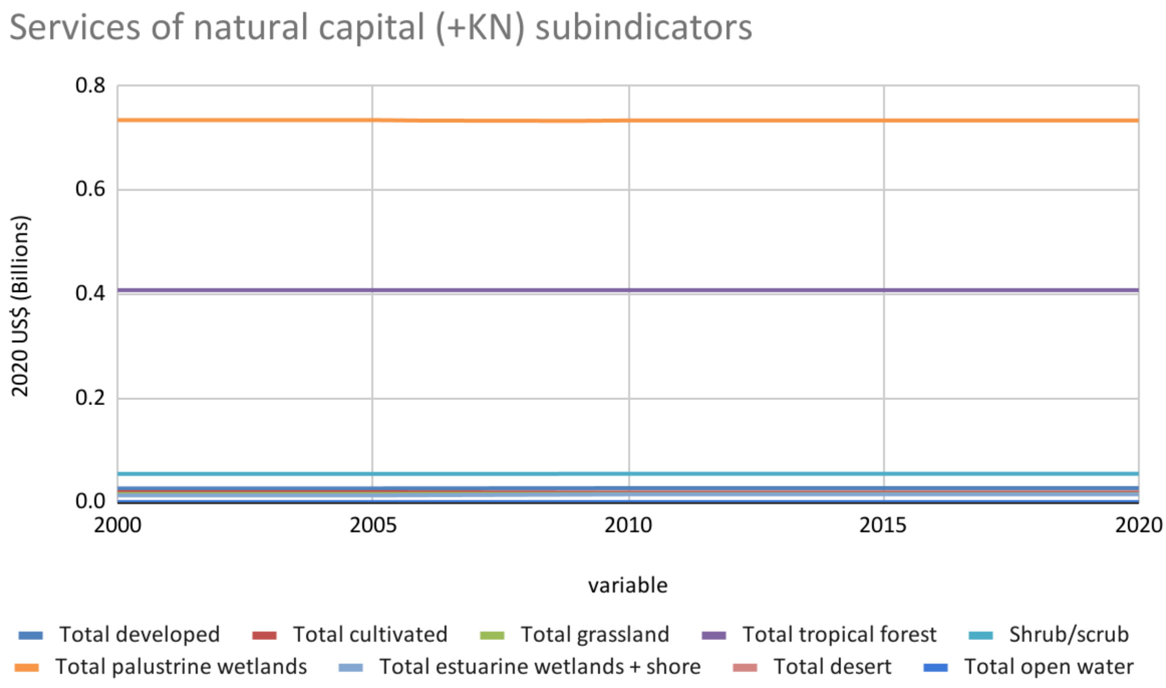


Figure 19 key take-aways:

- This indicator estimates the value of ecosystem services flowing from protected areas across a variety of biome types. Notably, land cover data for Hawai'i does not yet include offshore biomes, thus these are excluded from the estimates. Nine biomes are included: developed, cultivated, grassland, tropical forest, shrub/scrubland, palustrine wetlands, estuarine wetlands and shore, desert, and open (fresh) water.
- Hawaiʻi's highest valued protected areas are palustrine wetlands (representing 7% of area protected), followed by tropical forest (representing 35% of area protected).
- Directly transferring the benefit estimates from the ESVD database was problematic for non-use benefits from tropical forests in particular due to an outlier that skewed the overall mean. We therefore used the median for that service. This could bias downward the estimate of the value of forests.
- This indicator is affected by the same data limitation as -DKN/land conversion related to land cover data. Only two years of data are available, and the trend between those two years is extrapolated to all years. Maps of protected areas also require updating so the year of establishment of the park is apparent (we assumed all current parks were active across all years).

Figure 20. Services from protected areas, without palustrine wetlands and forests

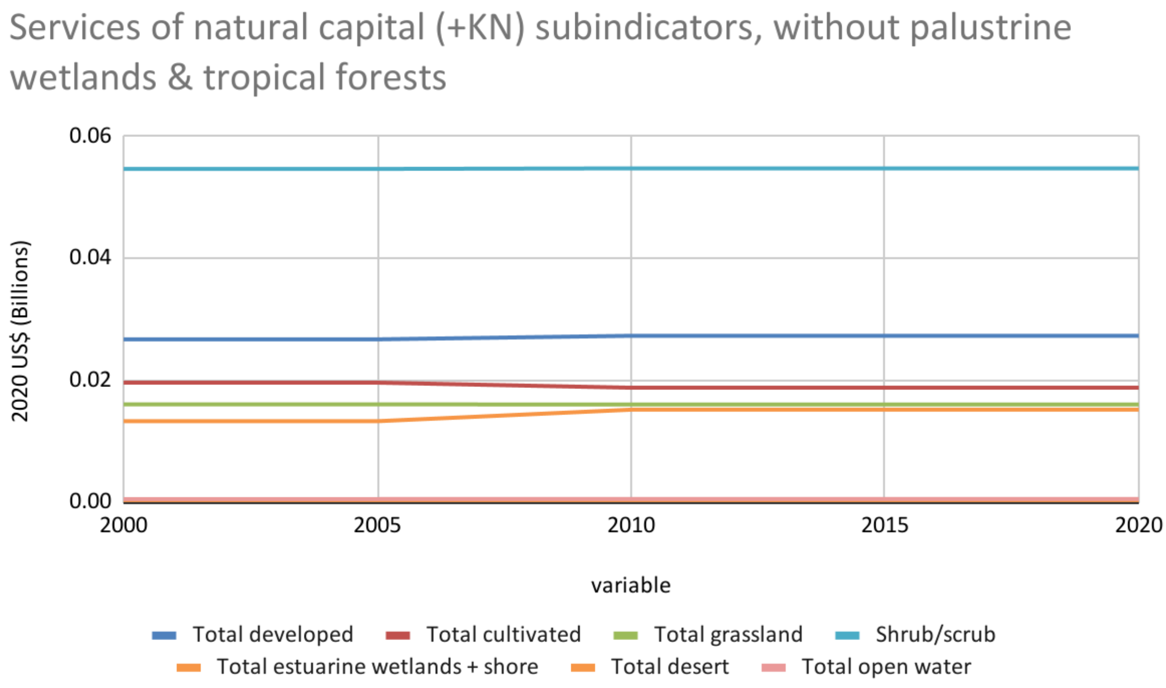


Figure 20 key take-aways:

- This figure presents the same data as the previous figure, but without the high values associated with palustrine wetlands and forests. Removing those two biomes facilitates examination of the other biomes that are otherwise overshadowed.
- The next highest valued land cover types after removing the two biomes are shrub/scrub (17% of protected area) followed by developed areas (<1% of area protected). Shrub/scrubland can provide important regulatory services, such as climate regulation, but the value is mainly driven by the area of shrubland protected. Protected areas exist within the developed biome in the form of green spaces, parks, etc. While very little in area is protected in the urban realm, its value is orders of magnitude higher per acre.
- Cultivated land provides market goods in terms of crops, though only non-provisioning services were included in the calculation as per GPI standards.
- Most values are fairly constant, in part due to the data limitations described above, leading to little variation in protected land cover area over the time period.

Figure 21. Utility and disutility by market vs. non-market components

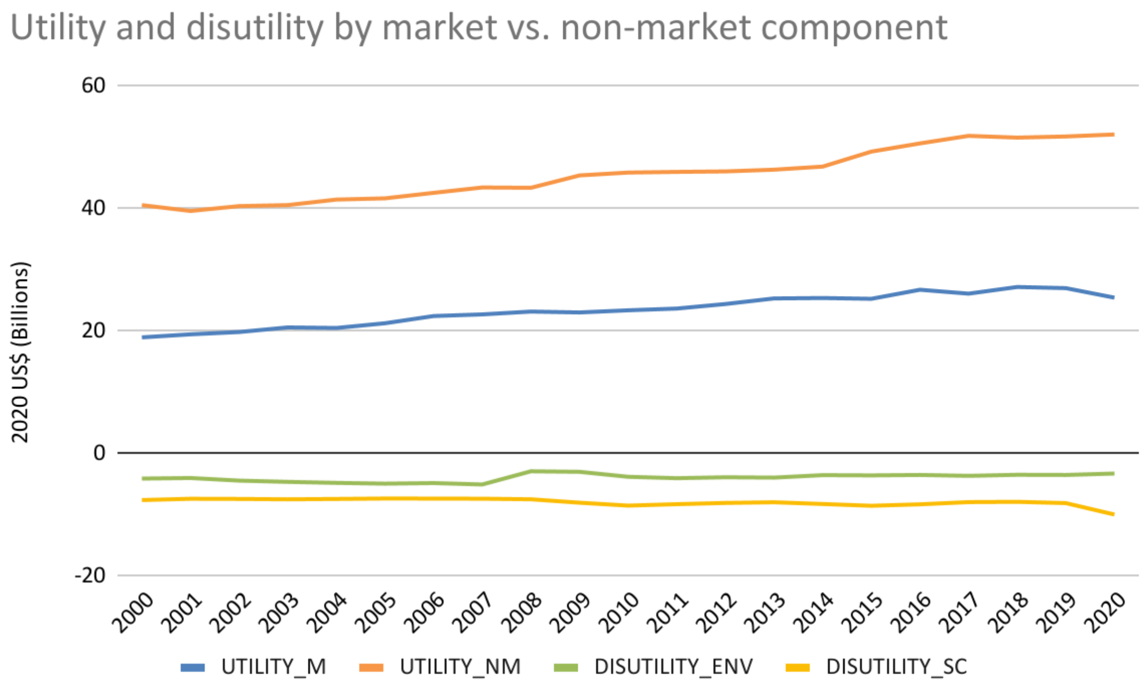


Figure 21 key take-aways:

- The utility-disutility framing parallels how Talberth and Weisdorf (2017) presented their findings. This framing splits the GPI into four components: market utility, non-market utility, environmental disutility, and social disutility.
- Market utility or UTILITY_M comprises adjusted PCE (inclusive of PCE, DEFR, HI, CDE, and INQ), and public provisioning of goods and services (PP). Non-market utility or UTILITY_NM derives from services from human, built, and natural capitals (+KH, +KB, and +KN).
- Environmental disutility (Disutility_ENV) comprises costs of pollution (POL) and loss of natural capital (-DKN), while social disutility (Disutility_SC) includes social costs (or -SC, inclusive of houselessness, underemployment, crime, commuting, and vehicle crashes).
- The value of non-market utility exceeds the value of market utility throughout the 20-year period. Both steadily increased across most of the study period.
- A rise in the non-market utility curve is noticeable in 2009 relative to 2008 and then again in 2015 compared to 2014. Underlying changes are seen in KH, more specifically with a change in unpaid work; changes in the services of consumer durables (KB) are mostly due to consumer durables.
- Social disutility grew over the study period (an undesirable trend). The social costs of the 2020 economic crisis are clear, driven by increases in underemployment and mediated by a slight decrease in commuting costs.
- Environmental disutility was greater (i.e., worse) than social disutility throughout the study period.

Figure 22. Utility and disutility by category

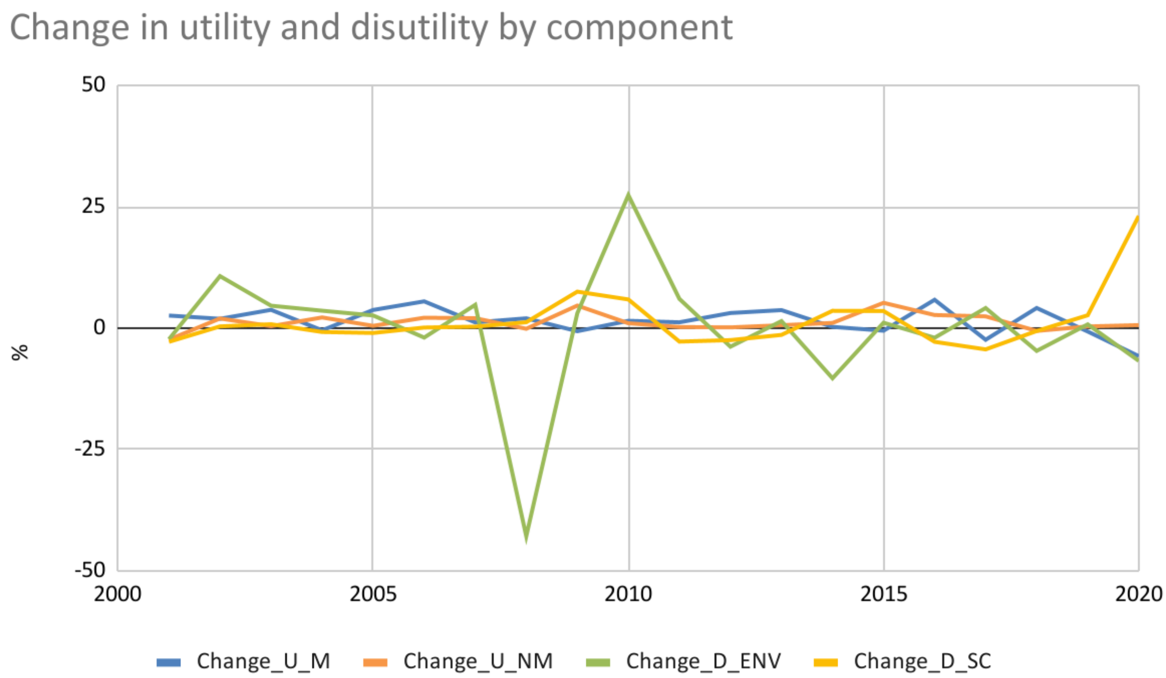


Figure 22 key take-aways:

- Positive growth in utilities (U_M and U_NM) is desirable. Negative change in disutilities (D_ENV and D_SC) is desirable.
- Negative growth in environmental disutility was driven by a drop in non-renewable energy consumption in 2008, although disutility increased again in 2010.
- Environmental disutility had positive growth most years pre-2012 (an undesirable trend). In the latter period, annual growth in environmental disutility was negative for about half the years.
- From 2002-2003, small levels of annual growth in both market and non-market utility coincided with large increase in environmental and slight increase in social disutility.
- 2020 saw a negative growth in market utility and a positive growth in social disutility (both undesirable), with some growth in non-market utility and decline in environmental disutility (both desirable).

5. Sensitivity Analysis

5.1. Defensive and regrettable expenditures (DEFR)

Previous GPI studies have used county-level data from ESRI to estimate consumption that is not welfare-enhancing. To evaluate the feasibility of this approach, we purchased ESRI data for 2020 for Hawai‘i and compared these to similar state level data from BEA. The ESRI data we received were only for the current year (i.e., 2020) as datasets from previous years are not available for sale, so approximating expenditures over the other 19 years of the study period was problematic. To estimate expenditures for years 2000 through 2019, we first found the ratio of personal consumption spent on a given item (e.g. tobacco) to total personal consumption from 2020, and then assumed the percentage remained constant for the previous years. This was an assumption that the project team and DBEDT advisors did not feel comfortable with, particularly as 2020 was an anomalous year due to COVID. BEA data, on the other hand, are available for all years of the study period. While ESRI data are reported down to the county level, BEA stops at state level, yet this is not a problem in our case as we are estimating GPI for the state. One large drawback of BEA data, however, is that they do not include estimates for some expenditures (such as legal, alimony, and child support) that are traditionally rolled into the GPI DEFR category.

Interesting results stemmed from a sensitivity analysis of ESRI versus BEA for 2020, especially since ESRI data are derived from BEA data originally. The DEFR estimates based on BEA data are far higher (almost 4 times) than those based on ESRI data (Table 7). The 20-year averages were $5.18 billion for ESRI versus $19.021 billion for BEA (in 2020$). This was largely driven by discrepancies in medical costs, which were far higher in BEA data (Figure 23). The results do not change our decision to use BEA for this version of GPI, but also do not preclude us from further exploring the applicability of ESRI data in future versions pending changes in data accessibility and available funding to purchase those datasets.

Table 7. DEFR comparison using ESRI and BEA data.

Sub Indicator	Average ESRI (Billion US$ 2020)	Average BEA (Billion US$ 2020)	BEA/ESRI (%)
Food & Alcohol	1.186	1.631	138%
Tobacco	0.162	0.576	356%
Insurance & Financial Services	1.230	4.079	332%
HH Pollution Abatement	0.3741	0.4845	129%
Medical & Legal Services (Legal Unavailable BEA)	1.339	10.025	749%
Food Waste	0.602	1.308	217%
Energy Waste	0.123	0.121	98%
Alimony & Child Support (Unavailable BEA)	0.136		
Lotteries	0.029	0.796	2775%
DEFR TOTAL	5.180	19.021	367%

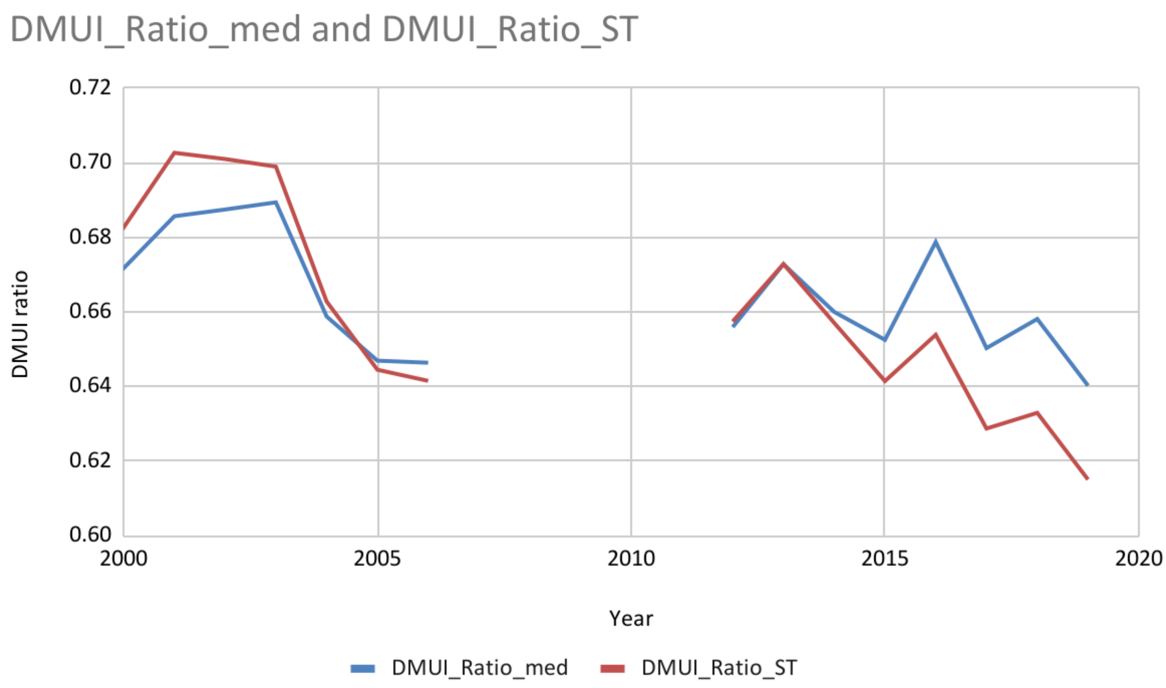
5.2. Income inequality

We explored two methods from the GPI literature to adjust for income inequality. The notion behind the adjustment is to de-value income (and thus consumption) at those income levels exceeding a certain threshold in order to reflect the diminishing marginal utility of consumption (DMUI) as income rises. The higher the income is above that set threshold, the more the personal consumption expenditure is discounted as each additional dollar of income brings less utility. The DMUI ratio then becomes the ratio of adjusted to unadjusted income. Therefore, the higher the income inequality in society, the lower the DMUI ratio.

We followed Talberth and Weisdorf (2017), who used a threshold of the median income, beyond which the welfare benefits of personal consumption expenditures are discounted. Figure 23 shows the diminishing marginal utility of income (DMUI) ratios from the two methods. The blue line (representing a threshold set at the median income each year) is the one applied in this analysis. Note that personal income data for Hawai‘i were not available for the years 2007-2011 and 2019-2020, therefore we interpolated a linear trend between 2006-2012 and extrapolated a 5-year trend to 2020 in our analysis. These were particularly volatile economic years with anomalies in income inequalities, thus filling these data gaps might change the ratio.

More recent work by Van der Slycken (2021) suggested using a sufficiency threshold, rather than the median. As the red line in Figure 23 illustrates, both methods show an increasing trend in the income gap. During most of our study period, the difference in the adjustment between the two methods was marginal. This is because both methods greatly discount very high incomes, which is where most income growth has occurred over the past two decades. Notably, in the years since 2015, growing income inequality in society is driving a (small, ~2.5 difference in DMUI ratio between the two methods) wedge between the two methods. The sufficiency threshold method does a better job of penalizing the growing income gap, and might be a modification DBEDT should consider if the income gap continues to grow.

Figure 23. Diminishing marginal utility of income ratio for both threshold methods (med = median; ST = sufficiency threshold)



5.3. Ecosystem services

Society benefits from well functioning ecosystems. GPI 2.0 estimates the value of ecosystem services from protected areas (e.g., flood protection, groundwater recharge), as well as the loss of these services from land cover change (e.g., loss of cropland, conversion of forests). The dollar value assigned to these flows of ecosystem services has been the subject of a broad literature over the past decades. A recent multi-institution effort, spearheaded by the Foundation for Sustainable Development, collected all valuation studies into a database, called the Ecosystem Services Valuation Database, or ESVD.

This open source, peer reviewed database is the best available compendium of values for biomes across the globe. Studies are collated by biome type and ecosystem service(s) the biome provides. The ESVD database provides monetary values per hectare of land type (in 2020$) for different ecosystem types. Those values are incorporated into two components of GPI: services of protected areas (+KN); and depletion of natural capital, specifically land use conversion. Hawai‘i GPI 2.0 matches land cover data for Hawai‘i in hectares and biome type with mean values per hectare of that biome taken from ESVD summary statistics of studies of that biome from across the world. Past GPI studies were faced with missing, scarce, and/or outdated valuation studies and likely underestimated the importance of the services provided by ecosystems; now having access to the ESVD using the best available data in standardized units helps to more properly monetize those critical natural capital assets.

That said, the ESVD is relatively new and many values are missing and/or inapplicable outside of their own context. Across the 15 biomes represented in the database, and across 23 provisioning and non-provisioning services, fewer than ⅓ have adequate estimates to calculate a mean in the summary statistics (i.e., more than five values published). While studies are broadly grouped by biome type, it is possible to further filter by geographical area, ideally narrowing down to those studies of the biome in a similar context. Yet studies are often heavily concentrated in certain geographical regions, limiting the ability to find a best fit aligned to the local context. ESVD recommends caution when transferring benefits of ecosystem services from one to another location. Another problematic estimate relates to non-use (i.e., bequest and existence) values, particularly of tropical forests. In our case, an outlier drove up the mean value by orders of magnitude, so we instead applied the median bequest/existence value for tropical forests to our calculations.

We moreover need to acknowledge that values people hold for ecosystem goods and services are difficult to monetize, particularly when values are deeply rooted in ethics. Values for ecosystems and their services are site-specific, so applying a global average is a poor substitute for localized studies. We recommend expanding local valuations for key ecosystem services that we know are critical to wellbeing in Hawai‘i. Key values for Hawai‘i relate to services from the ocean, coral reefs, wetlands, rivers, tropical forests, urban green/blue infrastructure, rangeland, and cultivated areas. Estimates are particularly sparse for cultural services, including for example spiritual experience or inspiration for culture stemming from nature, both of which are of great importance here in Hawai‘i.

To explore how sensitive our results are to assumptions about ecosystem values, we examined whether there were differences in non-provisioning value between protected and non-protected areas. In theory, these values could be different (e.g., restricting some uses might enhance recreational values). If these were different, we would apply a filtered value to the services from protected areas indicator (under +KN), and use the unfiltered ESVD value for the land conversion indicator (under -DNK). In the end, we found very little difference, apart from coral reefs (protected, non-provisioning value amounted to 65% of inclusive value) and coastal systems (in which case protected value was twice as valuable as the overall average).

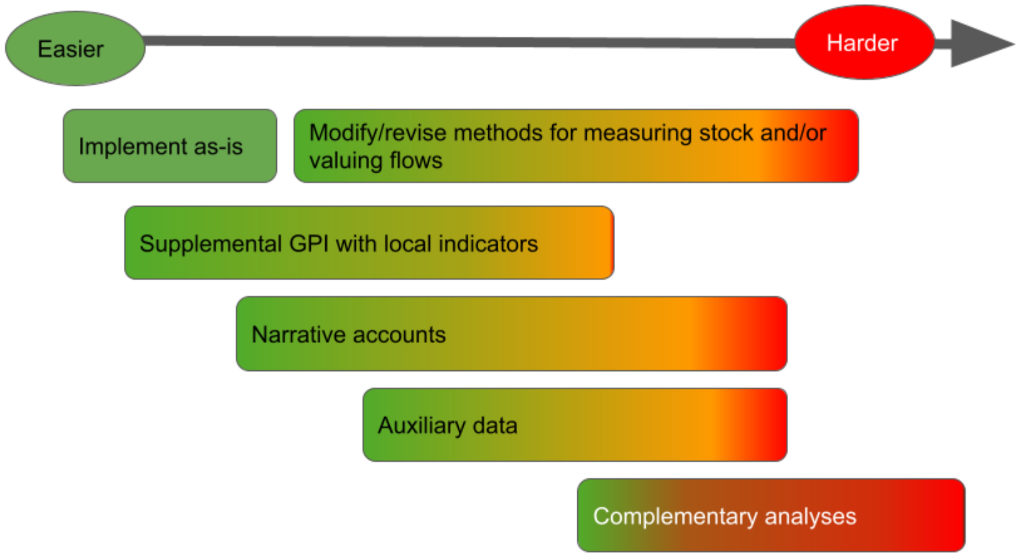
Future efforts to estimate the services from protected areas (+KN) and the losses from land conversion (-DKN) should focus on the two dimensions of these indicators, namely land use change and service flow value. Fortunately, Dr. Oleson has a research program in natural capital accounting analyzing land cover change and modeling and valuing ecosystem service flows. These results could tremendously improve the accuracy of these two indicators in Hawai‘i‘s GPI.

6. Continuing to Update Hawai‘i’s GPI

GPI represents a substantial advance over GDP in setting our state on a more balanced economic pathway. It is important to note, however, that **GPI does not meet the goal of ensuring that the “economy is at a sustainable scale.”** As explained in previous sections, GPI should be complemented by natural capital accounts, footprint analyses, and analysis of biocapacity, perhaps even system models that incorporate thresholds, to ensure that economic activity is not drawing down natural capital or degrading the environment to such a point as to threaten human wellbeing.

Figure 24 illustrates the next steps for the GPI project and their level of difficulty. These include moving beyond implementing GPI “as is” to broaden the exercise and aim for increased policy relevance. We review how far this project got for each step, and outline what could happen moving forward.

Figure 24. Level of effort required for next steps in developing Hawai‘i’s GPI



Step 1. We implemented one of the latest methods for GPI (Talberth and Weisdorf‘s) in this project. With some exceptions, their method reflects a Fisherian/narrower interpretation of GPI (“here and now”). It would be interesting to compare this to the broad/Hicksian GPI approach that captures **externalities in time and space** of current economic activity. We did not complete a Hicksian/broader “everywhere, anytime” analysis (van der Slycken’s) per agreement with DBEDT. The broader method would better reflect costs of economic activity in Hawai’i, as experienced globally and in the future, and therefore may better incorporate some considerations of equity and sustainability.

Step 2. Our project made some minor modifications to the Talberth and Weisdorf method, in large part to make up for data gaps. A potential next step would be to **modify and revise** the methods to address emerging critiques. One potential revision would be making accounting for greenhouse gas emissions more theoretically consistent with the “here and now” Fisherian income concept, from which Talberth and Weisdorf diverge for this single indicator. Another modification would be to use a sufficiency threshold instead of the median to adjust PCE for income inequality. Other proposed modifications for the social indicators are outlined in Appendix A, Table A-2.

Step 3. For some indicators, future efforts may want to **supplement** the as-is methods with local indicators of particular interest to Hawai‘i. The ease of quantifying these supplemental indicators will depend on the status of methods and availability of data. Key indicators that we may want to consider include change in coral reef (easy) and fisheries (moderately difficult due to data), the value of cultural practices (very difficult due to both methods and data), among others. Notably, Dr. Oleson (https://olesonlab.org) has a funded research program to map ecosystem change and value ecosystem service flows in Hawai‘i and hopes that future GPI teams look forward to incorporating findings.

Step 4. Because GPI is a composite indicator, albeit with decomposable parts, we suggest creating **narrative accounts** for some indicators for context and completeness. Narrative accounts could discuss distribution of costs and benefits, implications for human rights, issues related to gender, work-life balance, etc. The accounts would describe and analyze key issues, possible gaps, limitations, and drawbacks. See Table A-2 in Appendix A for more details.

Step 5. In some cases, **auxiliary data may be needed** to supplement key indicators to add additional information for interpretation. The focus should be on indicators that mask **underlying issues of social justice**. Auxiliary data may, for instance, disaggregate impacts. See Table A-2 in Appendix A for more details.

We want to highlight the need for **complementary analyses**. GPI is not a sustainability indicator. Natural capital accounts, global footprints, and biocapacity analysis could move Hawai‘i towards ecological sustainability. Similarly, sustainability assessment methodologies exist to assess social and environmental impacts of economic change.

Finally, we encourage DBEDT to take steps to ensure that the GPI analysis is taken up in policy. Such steps could include outreach and concrete demonstrations of how GPI can be used in policy analysis. Outreach to all the organizations listed in the Beyond GPI section of this report would help increase awareness of the GPI across interested stakeholder groups. We suggest compiling a webinar/talk using the materials included in the training slide decks and this report that DBEDT staff could deliver to diverse audiences. We look forward to working with DBEDT staff to explore how GPI can be used in policy analysis. Crafting examples of GPI being used as a tool or organizing framework to guide or evaluate policies is the natural next step of this research program.

7. Bibliography

Abrar, R. (2021). Building the Transition Together: WEAll's Perspective on Creating a Wellbeing Economy. In É. Laurent (Ed.), *The Well-being Transition: Analysis and Policy* (pp. 157–180). Springer International Publishing. https://doi.org/10.1007/978-3-030-67860-9_9

Agrawala, S., Dussaux, D., & Monti, N. (2020). *What policies for greening the crisis response and economic recovery?: Lessons learned from past green stimulus measures and implications for the COVID-19 crisis | READ online*. Oecd-Ilibrary.Org. https://read.oecd-ilibrary.org/environment/what-policies-for-greening-the-crisis-response-and-economic-recovery_c50f186f-en

Aitken, A. (2019). Measuring Welfare Beyond GDP. *National Institute Economic Review*, *249*(1), R3–R16. https://doi.org/10.1177/002795011924900110

Aloua, L. (2021). *We Da Waiwai*. University of Hawaiʻi Press. https://www.degruyter.com/document/doi/10.1515/9780824889159-021/html

Anielski, M. (2001). *The Alberta GPI blueprint: The Genuine Progress Indicator (GPI) sustainable well-being accounting system*. Pembina Institute for Appropriate Development.

Anielski, Na., & Rowe, J. (1999). *The Genuine Progress Indicator – 1998 Update*. Redefining Progress. https://www.yumpu.com/en/document/read/33724080/genuine-progress-indicator-1998-update-anielskicom

Bagstad, K. J., Berik, G., & Gaddis, E. J. B. (2014). Methodological developments in US state-level Genuine Progress Indicators: Toward GPI 2.0. *Ecological Indicators*, *45*, 474–485. https://doi.org/10.1016/j.ecolind.2014.05.005

Bagstad, K. J., & Shammin, M. R. (2012). Can the Genuine Progress Indicator better inform sustainable regional progress?—A case study for Northeast Ohio. *Ecological Indicators*, *18*, 330–341. https://doi.org/10.1016/j.ecolind.2011.11.026

Baker, M. T. (2018). Waiwai (abundance) and indigenous futures. In O. U. Rutazibwa & R. Shilliam (Eds.), *Routledge Handbook of Postcolonial Politics*. Taylor & Francis Group. http://ebookcentral.proquest.com/lib/uhm/detail.action?docID=5303556

Barrington-Leigh, C., & Escande, A. (2018). Measuring Progress and Well-Being: A Comparative Review of Indicators. *Social Indicators Research*, *135*(3), 893–925. https://doi.org/10.1007/s11205-016-1505-0

Berik, G. (2020). Measuring what matters and guiding policy: An evaluation of the Genuine Progress Indicator. *International Labour Review*, *159*(1), 71–94. https://doi.org/10.1111/ilr.12153

Berik, G., & Gaddis, E. (2011). *The Utah Genuine Progress Indicator (GPI), 1990 to 2007: A Report to the People of Utah*. www.utahpop.org/gpi.html

Beyond GDP: Measuring progress, true wealth, and the well-being of nations (European Commission). (n.d.). Retrieved May 28, 2021, from https://ec.europa.eu/environment/beyond_gdp/download/bGDP_website_background_paper.pdf

Bjørnholt, M., & McKay, A. (2014). *Counting on Marilyn Waring: New Advances in Feminist Economics*. Demeter Press.

Bleys, B. (2012). Beyond GDP: Classifying Alternative Measures for Progress. *Social*

Indicators Research, *109*(3), 355–376. https://doi.org/10.1007/s11205-011-9906-6
Bleys, B., & Whitby, A. (2015). Barriers and opportunities for alternative measures of economic welfare. *Ecological Economics*, *117*, 162–172. https://doi.org/10.1016/j.ecolecon.2015.06.021
Boffey, D. (2020, April 8). *Amsterdam to embrace "doughnut" model to mend post-coronavirus economy*. The Guardian. http://www.theguardian.com/world/2020/apr/08/amsterdam-doughnut-model-mend-post-coronavirus-economy
Böhringer, C., & Jochem, P. E. P. (2007). Measuring the immeasurable—A survey of sustainability indices. *Ecological Economics*, *63*(1), 1–8. https://doi.org/10.1016/j.ecolecon.2007.03.008
Borowy, I., & Schmelzer, M. (Eds.). (2017). *History of the Future of Economic Growth: Historical Roots of Current Debates on Sustainable Degrowth* (1st ed.). Routledge. https://doi.org/10.4324/9781315543000
Boyle, M. (2020, October 23). *The Great Recession Definition*. Investopedia. https://www.investopedia.com/terms/g/great-recession.asp
Bracco, S., Tani, A., Çalıcıoğlu, Ö., Gomez San Juan, M., Bogdanski, A., & Food and Agriculture Organization of the United Nations. (2019). *Indicators to monitor and evaluate the sustainability of bioeconomy: Overview and a proposed way forward*.
Brennan, A. J. (2008). Theoretical foundations of sustainable economic welfare indicators—ISEW and political economy of the disembedded system. *Ecological Economics*, *67*(1), 1–19. https://doi.org/10.1016/j.ecolecon.2008.05.019
Brickman, P., & Campbell, D. T. (1971). Hedonic relativism and planning the good society. In M. H. Appley (Ed.), *Adaptation-level theory* (pp. 287–305). Academic Press.
Brown, C., & Lazarus, E. (2018). Genuine Progress Indicator for California: 2010–2014. *Ecological Indicators*, *93*, 1143–1151. https://doi.org/10.1016/j.ecolind.2018.05.072
Bureau of Justice Statistics. (n.d.). *Prison Expenditures*. https://www.bjs.gov/index.cfm?ty=tp&tid=162
Christie, N. (2000). *Crime Control As Industry* (3rd ed.). Routledge.
Chrysopoulou, A. (2020, December 16). *The Vision of a Well-Being Economy (SSIR)*. https://ssir.org/articles/entry/the_vision_of_a_well_being_economy
Clemens, M., & Hamilton, K. (1999). Genuine Savings Rates in Developing Countries. *World Bank Economic Review*, *13*, 333–356. https://doi.org/10.1093/wber/13.2.333
Cobb, C., Goodman, G. S., & Wackernagel, M. (1999). *Why bigger is not better: The Genuine Progress Indicator 1999 Update*. Redefining Progress.
Cobb, Clifford, Halstead, T., & Rowe, J. (1995). *The genuine progress indicator: Summary of data and methodology*. Redefining Progress.
Costanza, R., Erickson, J., Fligger, K., Adams, A., Adams, C., Altschuler, B., Balter, S., Fisher, B., Hike, J., Kelly, J., Kerr, T., McCauley, M., Montone, K., Rauch, M., Schmiedeskamp, K., Saxton, D., Sparacino, L., Tusinski, W., & Williams, L. (2004). Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County and Burlington, from 1950 to 2000. *Ecological Economics*, *51*(1–2), 139–155. https://doi.org/10.1016/j.ecolecon.2004.04.009
Costanza, R., Hart, M., Kubiszewski, I., & Talberth, J. (2014a). *A Short History of GDP: Moving Towards Better Measures of Human Well-being* (No. 1). *5*(1), 7.
Costanza, R., Hart, M., Kubiszewski, I., & Talberth, J. (2014b). *A Short History of GDP: Moving Towards Better Measures of Human Well-being*. *5*(1), 7.

Costanza, R., Hart, M., Posner, S., & Talberth, J. (2009). *Beyond GDP: The Need for New Measures of Progress*. 46.

Costanza, R., Kubiszewski, I., Giovannini, E., Lovins, H., McGlade, J., Ragnarsdottir, K., Roberts, D., De Vogli, R., & Wilkinson, R. (2014). Time to leave GDP behind. *Nature*, *505*. https://art.torvergata.it/retrieve/handle/2108/91734/184621/nature.pdf

Coyle, D. (2014a). 1945 to 1975: The Golden Age. In *GDP* (REV-Revised, pp. 43–60). Princeton University Press. https://doi.org/10.2307/j.ctvc77mfx.6

Coyle, D. (2014b). 1995 to 2005: The New Paradigm. In *GDP* (REV-Revised, pp. 79–94). Princeton University Press. https://doi.org/10.2307/j.ctvc77mfx.8

Coyle, D. (2014c). Our Times: The Great Crash. In *GDP* (REV-Revised, pp. 95–122). Princeton University Press. https://doi.org/10.2307/j.ctvc77mfx.9

Coyle, D. (2014d). The Legacy of the 1970s: A Crisis of Capitalism. In *GDP* (REV-Revised, pp. 61–78). Princeton University Press. https://doi.org/10.2307/j.ctvc77mfx.7

Daly, H. E. (1987). The Economic Growth Debate: What Some Economists Have Learned But Many Have Not. *Journal of Environmental Economics and Management*, *14*, 323–336.

Daly, H. E., & Cobb, J. B. (1989). *For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future* (Second Edition). Beacon Press.

Daly, H. E., & Farley, J. (2011). *Ecological Economics: Principles and Applications*. Island Press.

Dolan, P., Layard, R., & Metcalfe, R. (2011). *Measuring Subjective Wellbeing for Public Policy: Recommendations on Measures* (No. 23; Special Paper, p. 23). London School of Economics.

Easterlin, R. A. (1974). Does Economic Growth Improve the Human Lot? Some Empirical Evidence. In P. A. David & M. W. Reder (Eds.), *Nations and Households in Economic Growth* (pp. 89–125). Academic Press. https://doi.org/10.1016/B978-0-12-205050-3.50008-7

Erickson, J. D., Zencey, E., Burke, M. D., Carlson, S., & Zimmerman, Z. (2013). *Vermont Genuine Progress Indicator*. Gund Institute. http://mediad.publicbroadcasting.net/p/vpr/files/VTGPI-Summary-30Jul13.pdf

European Commission. (2007, June 28). *Council Meeting Environment* [Text]. European Commission - European Commission. https://ec.europa.eu/commission/presscorner/detail/en/PRES_07_150

Fioramonti, L. (2017). Chapter 4 Gross domestic problem: How the politics of GDP shaped society and the world. In I. Borowy & M. Schmelzer (Eds.), *History of the Future of Economic Growth*. Routledge.

Fioramonti, L., Coscieme, L., & Mortensen, L. F. (2019). From gross domestic product to wellbeing: How alternative indicators can help connect the new economy with the Sustainable Development Goals. *The Anthropocene Review*, *6*(3), 207–222. https://doi.org/10.1177/2053019619869947

Fisher, I. (1906). *The Nature of Capital and Income*. Norwood Press.

Fleurbaey, M., & Blanchet, D. (2013). *Beyond GDP: Measuring Welfare And Assessing Sustainability*. Oxford University Press. https://vdoc.pub/documents/beyond-gdp-measuring-welfare-and-assessing-sustainability-74mkkkrmnsc0

Folbre, N. (2020). Cooperation & Conflict in the Patriarchal Labyrinth. *Daedalus*, *149*(1),

198–212. https://doi.org/10.1162/daed_a_01782
Folbre, N., & Nelson, J. A. (2000). For love or money—Or both? *The Journal of Economic Perspectives*, *14*(4), 123–140.
Fox, M.-J. V., & Erickson, J. D. (2018). Genuine Economic Progress in the United States: A Fifty State Study and Comparative Assessment. *Ecological Economics*, *147*, 29–35. https://doi.org/10.1016/j.ecolecon.2018.01.002
Fox, M.-J. V., & Erickson, J. D. (2020). Design and meaning of the genuine progress indicator: A statistical analysis of the U.S. fifty-state model. *Ecological Economics*, *167*, 106441. https://doi.org/10.1016/j.ecolecon.2019.106441
Fujiwara, D., Kudrna, L., & Dolan, P. (2014). *Quantifying and Valuing the Wellbeing Impacts of Culture and Sport*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/304899/Quantifying_and_valuing_the_wellbeing_impacts_of_sport_and_culture.pdf
Giovannini, E., & Rondinella, T. (2018). Going beyond GDP: Theoretical approaches. *Handbook of Research on Economic and Social Well-Being*. https://www.elgaronline.com/view/edcoll/9781781953709/9781781953709.00006.xml
Goosens, Y., Mäkipää, A., Schepelmann, P., van de Sand, I., Kuhndtand, M., & Herrndorf, M. (2007). *Alternative progress indicators to Gross Domestic Product (GDP) as a means towards sustainable development* (Studie Für Das European Parliament's Committee on the Environment IP/A/ENVI/ST/2007-10).
Hák, T., Janoušková, S., Abdallah, S., Seaford, S., & Mahony, S. (2012). *Review report on Beyond GDP indicators: Categorisation, intentions and impacts* (Brainpool, p. 109) [Project report]. www.brainpoolproject.eu
Halton, C., & Boyle, M. (2021, April). *Simon Kuznets Definition*. Investopedia. https://www.investopedia.com/terms/s/simon-kuznets.asp
Hayden, A. (2021). Chapter 7: From Fantasy to Transformation: Steps in the Policy Use of "Beyond-GDP" Indicators. In É. Laurent (Ed.), *The Well-being Transition: Analysis and Polcy*. Palgrave MacMillan.
Hayden, A., & Wilson, J. (2018). Taking the First Steps beyond GDP: Maryland's Experience in Measuring "Genuine Progress." *Sustainability*, *10*(2), 462. https://doi.org/10.3390/su10020462
Hicks, J. (1939). *Value and Capital* (Second Edition). Oxford University Press.
Hochschild, A. R. (2015). Emotion Work, Feeling Rules, and Social Structure. *American Journal of Sociology*. https://doi.org/10.1086/227049
Hoekstra, R. (2019). *Replacing GDP by 2030*. Cambridge University Press.
Hoekstra, R. (2020). *Measuring the Wellbeing Economy: How to Go Beyond GDP*. Wellbeing Economy Alliance.
IEA. (2020, June). *Sustainable Recovery – Analysis*. IEA. https://www.iea.org/reports/sustainable-recovery
Kaholokula, J., Ing, C., Look, M., Delafield, R., & Sinclair, K. (2018). Culturally responsive approaches to health promotion for Native Hawaiians and Pacific Islanders. *Annals of Human Biology*, *45*(3), 249–263.
Kanninen, T. (2012). *Crisis of Global Sustainability*. Taylor & Francis Group. http://ebookcentral.proquest.com/lib/hpu-ebooks/detail.action?docID=1105883
Kennedy, R. F. (1968, March 18). *Speech on 18 March 1968 at the University of Kansas*. http://www.jfklibrary.org/

Kenny, D. C., Costanza, R., Dowsley, T., Jackson, N., Josol, J., Kubiszewski, I., Narulla, H., Sese, S., Sutanto, A., & Thompson, J. (2019). Australia's Genuine Progress Indicator Revisited (1962–2013). *Ecological Economics*, *158*, 1–10. https://doi.org/10.1016/j.ecolecon.2018.11.025

Kubiszewski, I., Costanza, R., Franco, C., Lawn, P., Talberth, J., Jackson, T., & Aylmer, C. (2013). Beyond GDP: Measuring and achieving global genuine progress. *Ecological Economics*, *93*, 57–68. https://doi.org/10.1016/j.ecolecon.2013.04.019

Kubiszewski, I., Zakariyya, N., & Costanza, R. (2018). Objective and Subjective Indicators of Life Satisfaction in Australia: How Well Do People Perceive What Supports a Good Life? *Ecological Economics*, *154*, 361–372. https://doi.org/10.1016/j.ecolecon.2018.08.017

Kullenberg, C., & Nelhans, G. (2017). Measuring Welfare Beyond GDP: *Valuation Studies*, *5*(1), 7–38. https://doi.org/10.3384/VS.2001-5992.17517

Lahat, L., & Sened, I. (2020). Time and well-being, an institutional, comparative perspective: Is it time to explore the idea of a time policy? *Journal of European Social Policy*, *30*(3), 275–292. https://doi.org/10.1177/0958928719891339

Lawn, P. A. (2003). A theoretical foundation to support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and other related indexes. *Ecological Economics*, *44*(1), 105–118. https://doi.org/10.1016/S0921-8009(02)00258-6

Lawn, P. A. (2008). Response to "Income, sustainability and the 'microfoundations' of the GPI." *International Journal of Environment, Workplace and Employment*, *4*(1), 59. https://doi.org/10.1504/IJEWE.2008.022258

Llena-Nozal, Ana, Martin, N., & Murtin, F. (2019). *The economy of well-being: Creating opportunities for people's well-being and economic growth SDD WORKING PAPER No. 102*. https://read.oecd-ilibrary.org/economics/the-economy-of-well-being_498e9bc7-en

Mai, C., & Subramanian, R. (2015). *The price of prisons*. The Vera Institute. https://www.vera.org/publications/price-of-prisons-2015-state-spending-trends

Marcuss, R. D., & Kane, R. E. (2007). *U.S. National Income and Product Statistics: Born of the Great Depression and World War II*. 15.

McGregor, Daviana Pomaika'i, Morelli, P., Matsuoka, J., Rodenhurst, R., Kong, N., & Spencer, M. S. (2003). An ecological model of wellbeing. In H. A. Becker & F. Vanclay (Eds.), *The International Handbook of Social Impact Assessment: Conceptual and Methodological Advances* (p. 108). Edward Elgar Publishing.

McGregor, Davianna Pōmaika'i. (2007). *Nā Kua'āina: Living Hawaiian Culture*. University of Hawai'i Press.

McGuire, S., Posner, S., & Haake, H. (2012). Measuring Prosperity: Maryland's Genuine Progress Indicator. *Solutions*, *3*(2), 50–58.

McLaughlin, M., Pettus-Davis, C., Brown, D., Veeh, C., & Renn, T. (2016). *The Economic Burden of Incarceration in the United States* (WORKING PAPER # IJRD-072016). Institute for Justice Research and Development. https://ijrd.csw.fsu.edu/sites/g/files/upcbnu1766/files/media/images/publication_pdfs/Economic_Burden_of_Incarceration_IJRD072016_0_0.pdf

Messac, L. (2018). Outside the Economy: Women's Work and Feminist Economics in the Construction and Critique of National Income Accounting. *The Journal of Imperial and Commonwealth History*, *46*(3), 552–578.

https://doi.org/10.1080/03086534.2018.1431436
Muraca, B., & Schmelzer, M. (2017). Chapter 8 Sustainable degrowth: Historical roots of the search for alternatives to growth in three regions. In I. Borowy & M. Schmelzer (Eds.), *Economic Growth: Historical Roots of Current Debates on Sustainable Growth*. Routledge.
Nordhaus, W. D., & Tobin, J. (2018). Is Growth Obsolete? In P. Bartelmus & E. K. Seifert (Eds.), *Green Accounting* (1st ed., pp. 49–72). Routledge. https://doi.org/10.4324/9781315197715-3
Nugent, C. (2021, January 22). *Could Amsterdam's New Economic Theory Replace Capitalism? | Time*. https://time.com/5930093/amsterdam-doughnut-economics/
O'Donnell, G., & Oswald, A. J. (2015). National well-being policy and a weighted approach to human feelings. *Ecological Economics*, *120*, 59–70. https://doi.org/10.1016/j.ecolecon.2015.09.021
OECD. (2007). *European Commission—Environment*. https://ec.europa.eu/environment/beyond_gdp/index_en.html
OECD. (2021, May 27). *OECD Better Life Index*. http://www.oecdbetterlifeindex.org/about/better-life-initiative/
O'Neill, D. W., Fanning, A. L., Lamb, W. F., & Steinberger, J. K. (2018). A good life for all within planetary boundaries. *Nature Sustainability*, *1*(2), 88–95. https://doi.org/10.1038/s41893-018-0021-4
Ostergaard-Klem, R., & Oleson, K. L. L. (2014). Localizing the Genuine Progress Indicator to Hawaiʻi. *Environmental Practice*, *16*(3), 182–193. https://doi.org/10.1017/S1466046614000192
Ostergaard-Klem, R., Oleson, K. L. L., & Environmental Council of Hawaiʻi. (2013). *Environmental Council Annual Report 2013, State of Hawaiʻi: Presenting the genuine progress indicator baseline*. Office of Environmental Quality Control.
Papa Ola Lokahi. (n.d.). *Native Hawaiian Health Publications*. Native Hawaiian Health Publications. Retrieved May 28, 2021, from http://www.papaolalokahi.org/native-hawaiian-information/publications.html
Peterson, L. (2014). The Measurement of Non-economic Inequality in Well-Being Indices. *Social Indicators Research*, *119*(2), 581–598. https://doi.org/10.1007/s11205-013-0513-6
Prison Policy Initiative. (n.d.). *Hawaiʻi profile*. Retrieved May 28, 2021, from https://www.prisonpolicy.org/profiles/HI.html
Raworth, K. (2013, April 28). *Doughnut | Kate Raworth*. https://www.kateraworth.com/doughnut/
Roberts, C. (2020, June 3). *Making GDP the focus of a post-coronavirus economy would be a mistake | Carys Roberts*. The Guardian. http://www.theguardian.com/commentisfree/2020/jun/03/post-coronavirus-economy-gdp-growth-green-economy-million-jobs
Rockström, J. (n.d.). Thriving Within Planetary Boundaries—To Prosper the World Needs a Great Transformation to Global Sustainability. *Center for International Relations and Sustainable Development (CIRSD) Horizons*.
Samuelson, P. A. (1961). The Evaluation of 'Social Income': Capital Formation and Wealth. In F. A. Lutz & D. C. Hague (Eds.), *The Theory of Capital: Proceedings of a Conference held by the International Economic Association* (pp. 32–57). Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-08452-4_3

Sawyer, W., & Wagner, P. (n.d.). *Mass Incarceration: The Whole Pie 2020*. Prison Policy Initiative. Retrieved May 28, 2021, from https://www.prisonpolicy.org/reports/pie2020.html

Sen, A. (1990). Development as capability expansion. In *The Community Development Reader* (pp. 41–56).

Shrotryia, V. K., & Singh, S. V. P. (2020). Measuring Progress Beyond GDP: A Theoretical Perspective. *Emerging Economy Studies*, *6*(2), 143–165. https://doi.org/10.1177/2394901520983784

Stiglitz, J. E., Fitoussi, J.-P., & Durand, M. (2018). *Beyond GDP: Measuring What Counts for Economic and Social Performance*. OECD. https://read.oecd-ilibrary.org/economics/beyond-gdp/executive-summary_9789264307292-3-en

Strand, J., & Toman, M. (2010). *"Green Stimulus," Economic Recovery, And Long-Term Sustainable Development*. The World Bank. https://doi.org/10.1596/1813-9450-5163

Talberth, J., Cobb, C., & Slattery, N. (2007). *The Genuine Progress Indicator 2006*. 33.

Talberth, J., & Weisdorf, M. (2017). Genuine Progress Indicator 2.0: Pilot Accounts for the US, Maryland, and City of Baltimore 2012–2014. *Ecological Economics*, *142*, 1–11. https://doi.org/10.1016/j.ecolecon.2017.06.012

The Economist. (2016). *The trouble with GDP; Measuring economies—Document—Gale In Context: U.S. History*. https://go-gale-com.hpu.idm.oclc.org/ps/retrieve.do?tabID=Magazines&resultListType=RESULT_LIST&searchResultsType=MultiTab&hitCount=1&searchType=AdvancedSearchForm&currentPosition=1&docId=GALE%7CA451181862&docType=Article&sort=Relevance&contentSegment=ZXAG-MOD1&prodId=UHIC&pageNum=1&contentSet=GALE%7CA451181862&searchId=R1&userGroupName=hono53192&inPS=true

Thiry, G. (2015). Beyond GDP: Conceptual Grounds of Quantification. The Case of the Index of Economic Well-Being (IEWB). *Social Indicators Research*, *121*(2), 313–343. https://doi.org/10.1007/s11205-014-0650-6

UN. (1992). *Future We Want .:. Sustainable Development Knowledge Platform*. https://sustainabledevelopment.un.org/rio20/futurewewant

UN. (2021). *System of Environmental Economic Accounting*. https://seea.un.org/content/ecosystem-accounting-news

UNDP. (2021, May 27). *Human Development Index (HDI) | Human Development Reports*. http://hdr.undp.org/en/content/human-development-index-hdi

United Nations (Ed.). (2007). *Indicators of sustainable development: Guidelines and methodologies* (3rd ed). United Nations.

van den Bergh, J. C. J. M. (2009). The GDP paradox. *Journal of Economic Psychology*, *30*(2), 117–135. https://doi.org/10.1016/j.joep.2008.12.001

van den Bergh, J. C. J. M. (2010, April 13). The virtues of ignoring GDP - dropping a bad habit. *The Broker: Connecting Worlds of Knowledge*. https://www.thebrokeronline.eu/the-virtues-of-ignoring-gdp-d40/

Van der Slycken, J. (2021). *Beyond GDP: Alternative measures of economic welfare for the EU-15*. Universiteit Gent.

Van der Slycken, J., & Bleys, B. (2020). A Conceptual Exploration and Critical Inquiry into the Theoretical Foundation(s) of Economic Welfare Measures. *Ecological Economics*, *176*, 106753. https://doi.org/10.1016/j.ecolecon.2020.106753

Wagner, P., & Rabuy, B. (2017). *Following the Money of Mass Incarceration* (No. 25). Prison

Policy Initiative.
Waring, M. (2003). Counting for something! Recognising women's contribution to the global economy through alternative accounting systems. *Gender & Development*, *11*(1), 35–43. https://doi.org/10.1080/741954251
Waring, M. (2018). *Still Counting: Wellbeing, Women's Work and Policy-making*. Bridget Williams Books.
WEAll. (2021, May 30). The Wellbeing Economy Alliance. *Wellbeing Economy Alliance*. https://wellbeingeconomy.org/about
Wikipedia. (2021, April 10). *Genuine Progress Indicator*. Genuine Progress Indicator. https://en.wikipedia.org/wiki/Genuine_progress_indicator
Williams, T. K. (2020). *MANAgement in KANAKAnomics: Kanaka Maoli Approaches of Organizational Behavior and Theory, Economic Strategy, and Entrepreneurship* [UC Riverside]. https://escholarship.org/uc/item/2z35q3sr
World Bank. (n.d.). *How does the World Bank classify countries? – World Bank Data Help Desk*. Retrieved May 31, 2021, from https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries
World Bank. (2020, June 8). *The Global Economic Outlook During the COVID-19 Pandemic: A Changed World*. World Bank. https://www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-world
Wu, J., & Wu, T. (2012). SUSTAINABILITY INDICATORS AND INDICES: AN OVERVIEW. *Handbook of Sustainability Management*, 22.
Zencey, E. (2018). *The 2018 Vermont Genuine Progress Indicator Report* (p. 106). University of Vermont. https://spotlight.vermont.gov/sites/spotlight/files/Performance/GPI/2018_VT_Genuine_Progress_Indicators_Report.pdf

Appendix A Tables

Table A-1. Comparison of indicators & methods across Ostergaard-Klem & Oleson (2014), Talberth & Weisdorf (2017) and Van der Slycken & Bleys (2020) with working comments for Hawaiʻi

O&O 2014	VdS 2021	T&W 2017
GPI = PCE(adj) + G + W - D - S - E - N	GPI = Cadj + G + UW - BEC	GPI = U(HBE - DEFR - HI)*INQ + PP + U(KH+KB+KN) + U(DKN + POL + SC + RU)

Indicator	Description/ Justification	Methodology O&O 2014	Methodology VdS 2021	Methodology T&W 2017	Hybrid approach (what did we choose)
GPI = (C - DEFR - CD - HH + CS)*INQ + G + PP + KH + KB + KN - BEC - NEC - SS - DKN - NCG					
Consumption Expenditure (+C)	Household/individual annual consumption, the base for which GPI adjustments are made.	1997-2019: BEA SIPA reports Personal Consumption Expenditure for State of Hawaiʻi. 1960-1997 requires calculation: *(National Consumption / National Income) x Hawaiʻi Personal Income / CPI-U*	Utilizes Eurostat data for Actual Individual Consumption, which includes individual consumption expenditure by household, government, and non-profit institutions serving households (AIC).	Utilizes ESRI data for PCE (relabled Household Budget Expenditure (HBE)), which is more accurate than personal consumption data from NIPA accounts. Adjusted using national and regional CPIs.	1997-2019: BEA SIPA reports Personal Consumption Expenditure for State of Hawaiʻi. 1960-1997 requires calculation: *(National Consumption / National Income) x Hawaiʻi Personal Income / CPI-U*
Public & Non-profit provision of goods and services (+PP)	The annual value of non-defensive goods and services consumed by households/individuals but produced by public or non-profit entities.		VdS includes in AIC.	Adds public and non-profit provision of goods and services (for example, arts and cultural events, food, energy, housing) using NIPA account line items. Cautions that these items may include durable goods or defensive expenditures.	
Defensive and Regrettable Expenditures (-DEFR)	Welfare harmful or welfare neutral expenditures to be	Defensive and regrettable expenditures are not deducted	All or portions of the below defensive and regrettable	All or portions of the below defensive and	

	deducted from Consumption Expenditure (C).	in original Hawai'i GPI; cost of pollution abatement was included as a separate indicator.	expenditure categories are identified and subtracted from C.	regrettable expenditures categories are identified and subtracted from C.	
Food and alcohol	Welfare neutral		25% of food and alcohol expenditures are deducted.	25% of alcohol expenditures are deducted.	
Tobacco and Narcotics	Welfare negative		100% of tobacco and narcotics expenditures are deducted.	100% of tobacco expenditures are deducted.	
Insurance and Financial Services	Insurance serves to defend utility from unbeneficial economic activity, not part of ultimate consumption. Financial services are intermediaries, not contributing to final consumption.		100% of insurance and financial service expenditures are deducted.	Insurance expenditures are deducted.	
Cost of Road Accidents	Welfare negative		100% of the cost of road accidents are deducted. Calculated by using direct and indirect cost estimates for road accident injury and fatality.		
HH pollution abatement	Defensive expenditure.	*Cost of personal pollution abatement for air pollution = number of new personal vehicles x ($100 for catalytic converter per vehicle+$8.50 for air filter per vehicle)* *Cost of personal pollution abatement for solid waste = state population x 1.39 tons/person/year x $100/ton* *Costs of personal pollution abatement for wastewater = number of households with sewer connections x typical sewer fees per year + number of households with septic systems x 15 x fees for*		Household pollution abatement technology and security systems expenditures are deducted.	

		pumping			
Medical and legal services	Welfare neutral			Medical care and legal services expenditures are deducted.	
Food Waste	The cost of expenditures on food that is wasted.			According to NRDC, 25% of food is wasted at home and 19% in restaurants; these estimates are applied accordingly to ESRI line items.	
Energy waste	Understood as the difference between current energy consumption and energy consumption with best available technologies (T&W).			BAT published in local climate action plans estimate energy savings specific to Maryland and Baltimore at 16% for electricity and 42% for natural gas. U.S. estimates from McKinsey & Company are 12% and 9% respectively.	
Alimony and Child Support	Expenditures on alimony and child support is considered welfare neutral.			Deducts	
Lotteries	Expenditures on lottery tickets are regrettable and not welfare enhancing.			Deducts	
HH investments (-HH)	Portion of consumption that are investments and thus should be removed from C as their services will be accounted for.			In addition to consumer durables, T&W include household repairs/maintenance, home improvement, higher and vocational education, savings, investment, and retirement, & charitable giving, all available in ESRI dataset.	
Household repairs/ maintenance	Services from these investments			Detailed line items in	

and home improvement	will be accounted for in the services from built capital indicator (KB).			ESRI data allow for deductions of these investments.	
Higher and Vocational Education	Education can be viewed both as consumption, in that it benefits one's utility, as well as investment, in that it improves labor market outcomes.			T&W assume that primary and secondary are consumption, while higher/vocational education expenditures are investment in human capital (KS).	
Savings, Investment, Retirement	These are investments by definition, not consumption.			Detailed line items in ESRI data allow for deductions of these investments.	
Charitable Giving	Expenditures on charitable giving are accounted for as investment in social capital (KS) rather than household consumption.			Detailed line items in ESRI data allow for deductions of these investments.	
Consumer Durable Expenditures (-CDE)	Expenditure costs of consumer durables, including clothing, footwear, furnishings, household equipment, and vehicle purchases, to be deducted from Consumption Expenditures (C).	Because there were no data for stock of capital in the state economy, national data are down-scaled. *Cost of Consumer Durables - (Personal Income Hawai'i x National % of income spent on durables) / CPI-U*	Deducts Eurostat durable goods, data does not include semi-durable goods.	Deducts standard consumer durable expenditures.	1997-2019: BEA NIPA provides state spending on consumer durable; 1960-1997: *National Consumer Durable Expenditures / National Income x Personal Income Hawai'i / CPI-U*
Clothing & Footwear	Included in standard consumer durable calculations.	Doesn't specify in write up? NIPA handbook classifies these as non-durable, so not sure what was included here.	Doesn't specify	Deducts	
Appliances & Furnishings	Included in standard consumer durable calculations.	Doesn't specify in write up?	Doesn't specify	Deducts	
Vehicles	Included in standard consumer durable calculations.	Doesn't specify in write up?	Doesn't specify	Deducts	

Cost of Income Inequality (-INQ)	To account for diminishing marginal utility of income (DMUI), net consumption is adjusted for income inequality using the DMUI approach normalized at a sufficiency threshold.	The Gini Index is used to adjust consumption for inequality.	A DMUI elasticity of ρ=1.26 is applied to deciles above the poverty sufficiency threshold and summed; this aggregate is then divided by the unadjusted income to yield the portion of consumption remaining after inequality adjustments, the inverse of which is deducted from C as welfare losses.	*Adj = m*log(x/m)+m* Above equation is applied to household income above the median (below median is assumed linear DMUI), where household incomes are grouped into brackets of $5,000 (with $250,000 upper limit). The adjusted mean incomes of each bracket are multiplied by the number of taxpayer filings to establish utility-adjusted total income, which is then summed and divided by the unadjusted total income to create INQ.	
Consumer Durable Services (+CDS)	Because Consumer Durables provide services beyond the initial year of purchase, consumer durable services are to be spread over an assumed eight years, at a depreciation rate of 12.5%, and interest rate of 7.5% (totally 20%).	Following the standard assumption that capital lasts eight years, the services are calculated as 20% of the stock, where the stock is the sum of the previous eight years of consumer durable costs.	Following the standard assumption that capital lasts eight years, the services are calculated as 20% of the stock, where the stock is the sum of the previous eight years of consumer durable costs. Notes a 7.5% interest rate may be unnecessarily high post-recession.	Follows standard of valuing services from durables at 20% of the stock.	
Services of Highways and Streets	Just as consumer durables provide ongoing services beyond the initial purchase, streets and highways provide ongoing services beyond the initial cost to construct them.	Utilizes data for actual miles of roadway in Hawaiʻi to find the ratio of Hawaiʻi roads to the national total; those data from 1998 to 2012 were readily available from DBEDT Data Book over various years. Prior to 1998, utilizes an assumed ratio of Hawaiʻi to US road miles of 0.108 % based on the trends in the available data. Next multiplies the ratio of state to national miles by the value of		Values services from highways and streets at 7.5%.	

		the national stock of streets and highways published by BEA (data: Government Fixed Assets for Highways and Streets from Table 11 Current-Cost Net Stock of Government Fixed Assets). To arrive at an annual value for non-commuting services provided by the streets and highways in Hawai'i, adopts the same adjustment factor from past GPI studies. (Depreciation rate 2.5 %, and a interest rate, 7.5 %, and the percentage of vehicle miles used for everything except commuting as 7.5 %.			
Non-defensive Government Expenditures (+G)	100% of government expenditures on welfare enhancing public services. Note: wouldn't include this *and* public consumption expenditures in PP indicator bc double counting.		Sum of non-defensive government expenditures, including general public services, housing and community amenities, and recreation, culture, and religion (while environmental protection, education, etc. are seen as defensive).		
Services from social/human capital (+KH)	Services from investments in human capital are accounted for by estimating social payoffs. Note: some GPI studies choose not to include higher education specifically, countering that associated benefits are captured by way of other GPI indicators such as increased personal consumption expenditures	Services from investments in human capital are accounted for by estimating social payoffs.		As standard, stock metrics are compiled and then multiplied by unit values that reflect annual social payoff.	
College Graduates	Higher education provides positive externalities to society to be accounted for.	Utilized US census data on college graduates =<25yo that were available for the years of 1990, 2000, 2006-2009. Interpolation was used for all		Utilizes Census Data for share of population +>25yo with Bachelor's degrees. Keeps with standard US GPIs in	

		other years not available after 1990. The value of $16,000 in 2000 USD was applied to each graduate as per Maryland (2010) and Talberth et al., (2007).		using $16,000 per graduate for social payoff.	
Manufacturing Jobs	Manufacturing jobs provide positive externalities to society to be accounted for.			Utilizes BLS local and state data on manufacturing jobs, and assigns an external benefit value of $10,000 per job year based on willingness to pay analyses from BLS between 2009-2011.	
Green Jobs	Green jobs provide positive externalities to society to be accounted for.			Extrapolates BLS 2011 data for green job share in various employment categories (notably, an underestimate as green jobs have increased). Utilized an external benefit estimate of $100,000 per green job year to account for the social payoffs, also notably an underestimate (given some estimates as high as $325,000 (Bond, 2009)).	
Unpaid Work (+UW)	Non-market unpaid work, including volunteer work, housework, and caregiving provide beneficial social services to be accounted for.	For housework: utilizes the American Time Use Survey (ATUS) national data on housework hours and adjusts according to the ratio of HI population 15yo +. This figure is then multiplied by the wage rate of housekeeping workers in Hawai'i retrieved from table 12.31 in the 2012 State of Hawai'i Databook from the DBEDT. For volunteer work: the	Standard is to use a replacement cost for market substitute, but Brown and Lazarus (2018) propose using an opportunity cost (i.e., valuing at average wage).	Includes non-market time from volunteering, housework, and caregiving. Applies standard GPI approach based on American Time Use Survey (ATUS) data on hours spent on each non-market labour category multiplied by the market cost of substitutable paid labor.	Hours un-paid work * $X/hr. Livable wage v market wage substitute

		estimated monetary value per hour of volunteer work was multiplied by the number of hours spent per year. The number of total volunteer hours in the state of Hawaiʻi was found via the “Volunteering and Civic Life in America” website. The hourly “volunteer” wage rate has been valued by the Federal Agency for Service and Volunteering ($18.14).			
Leisure	Leisure hours enhance personal utility and are included as a welfare measurement. Note: if leisure is credited as a service, lost leisure time should not be deducted later on due to double counting.			Utilizes ATUS data on annual workday leisure hours and multiplies the hours by the opportunity cost (or post-tax median wage).	Note: Talberth credits rather than deducts; to discuss.
Internet	Captures positive externality of internet connection access.			Utilizes Census Data to estimate the population (3yo+) with home internet, then multiplies that population by the mean of two estimates for consumer surplus of free services per user per year ($591) from The Economist 2013; Brynjolfsson and Oh, 2012.	
Cultural practices	Separate out from unpaid work/volunteering?				Add component?
Services built capital (+KB)	Because T&W add Household Improvements to Consumer Durables, as additional non-consumption items to be subtracted from PCE, they must account for these investment services later on.			Follows a similar approach to Consumer Durable Services.	
Transportation	Transportation infrastructure			Utilizes US NIPA account	

	provides long-term social benefits to be spread over time.			data on current net of depreciation stock values and the corresponding per capita values for local jurisdiction. These current stocks are then multiplied by 7.5% as an estimate for annual services.	
Water Infrastructure	Water infrastructure provides long-term social benefits to be spread over time.			Utilizes US NIPA account data on current net of depreciation stock values and the corresponding per capita values for local jurisdiction. These current stocks are then multiplied by 7.5% as an estimate for annual services.	
Household Improvements	Accounting for the services of the Household Improvements that were deducted from above Consumption.			As with consumer durables, the stock year is calculated as the accumulation of the previous eight years of expenditures in the Household Investment indicator minus the standard 12.5% depreciation value. Expenditures in the current year are then added to the stock year calculation, and 20% of that final value is then added to the GPI as value of annual services.	
Services protected areas (+KN)	Natural capital provides vast ecosystem services that enhance utility, some of which can be directly linked to economic activity and investments.			Focuses on non-commercial use protected areas because commercial use at protected areas may degrade land and/or already be accounted for in market based GPI components.	

By land cover	T&W only include services from protected areas in their calculation for services from natural capital, as protected areas are justified as having direct relation to conservation investment.			Utilizes USGS National Land Cover Database (NLCD) and USGS National Gap Analysis Program's protected area database to estimate a stock of the State's protected areas managed for non-commercial use. These stocks are grouped into nine land cover types, which are then multiplied by ecosystem service estimates from similar land cover types in previous studies.	
Cultural Sites?	Would be a novelty				
Local pollution costs (-NEC)	Local pollution costs associated with economic activity are deducted because they are not welfare enhancing.	Local pollution costs associated with economic activity are deducted because they are not welfare enhancing.	Methodology varies depending on "narrow" versus "broad" approach.	Local pollution costs associated with economic activity are deducted because they are not welfare enhancing.	
Air	Air pollution is largely an outcome of economic activity and has a negative effect on utility.	*GPI Hawai'i did not include air pollution; only cost of ozone depletion.* *Cost of ozone depletion (1960 – 2004) = (tons of emissions of CFCs at national level) x (state population/national population) x ($49,669 per ton CFC)* Extrapolated US share of global emissions in ozone depleting chemicals through 2004, after which they become negligible.	Multiplies within border air pollution from six criteria air pollutants using Eurostat emissions data by cost estimates for each pollutant using European Environmental Agency analyses based on health and climate related costs.	Utilizes marginal damage estimates from Muller and Mendelsohn (2007) for six criteria air pollutants to determine cost of emissions, following Berik and Gaddis (2011).	Include air pollution, as it does exist in HI and can cause problems for certain vulnerable groups
Greenhouse gas	Greenhouse gas emissions are largely an outcome of economic activity and have a negative effect on utility.	Utilized Energy Information Administration data on amount of coal, natural gas, petroleum, and wood and waste consumed, and then converted these to tons CO2 emissions		Follow standard approach of coupling inflation-adjusted social cost of carbon (mean $93 per ton) with ghg emission State level data	

		based on carbon equivalence rates reported by the State Energy System Database (EIA SEDS), and then valued each ton by Tol's cost per ton CO2. Converted Tol's value per ton C to $25.4 per ton CO2. Similar to the other studies, then interpolated a linear trend between 1963 ($0 damages) and 2004 ($25.4 per ton CO2), and extrapolate that trend through time horizon.		from EPA.	
Water	Water pollution is largely an outcome of economic activity and has a negative effect on utility.	*Cost of water pollution = (State population) x ($130 per capita) x (% degraded streams)*	VdS and Bleys propose removing this subindicator, and instead including estimates of reactive nitrogen lost from agriculture to waterways.	Utilizes US EPA data on impaired waters in eight aquatic ecosystems coupled with willingness to pay (WTP) analyses for restoration compiled by TEEB, Earth Economics, etc (A.9).	
Noise	Noise pollution is largely an outcome of economic activity and has a negative effect on utility.	*Cost of noise pollution = National cost of air pollution from WHO a analysis x (state urban population/US urban population)*		Pioneers vehicles as a proxy for noise pollution, by combining vehicle miles traveled data with marginal damage cost estimates from the Federal Highway Administration (FHWA).	What about airports and military bases?
Solid waste	Solid waste is largely an outcome of economic activity and has a negative effect on utility.			Multiplies annual volume of solid waste in the jurisdiction by Kinnaman's (2009) public external cost for solid waste estimate ($19.26/ton), which is likely an underestimation of true social costs.	
Cost of extreme weather events	Captures current damages suffered from climate change being experienced here and now (i.e. BCE/NEC approach).		Should not be included with Costs of Climate Damages due to Emissions (BEC) because of double counting.		

			Focuses on uninsured costs of weather events in order to account for positive externality of insurance utilization. Utilizes Munich Reinsurance Company's NatCatService for data on uninsured losses. Final cost is difference between aforementioned data and direct economic loss estimates.		
Nitrogen *(-NEC and - BEC)*	Captures the current ecosystem costs within domestic borders of nitrogen pollution.		Included in both NEC and BEC, calculated by coupling emissions data (NOx and NH3) from Eurostat, with cost estimates of nitrogen pollutions' impact on ecosystems (excluding impacts on health and climate already captured in air pollution sub indicator) (Van Grinsven 2013).		
Global environmental and social costs (-BEC)	Captures social and environmental costs experienced outside of the jurisdiction's borders and into the future; thus only included in the BCPA/BEC approach.		Captures future and distant environmental and social costs, beyond current local costs.		
Climate damages due to emissions	Captures future and distance costs of climate change (BCPA/BEC approach). Does not include here and now costs of climate change, which are accounted for in the Costs of Extreme Weather Events (BCE/NEC) subindicator.		Should not be included with Costs of Extreme Weather Events (NEC) because of double counting. Calculated by standard approach of coupling social cost of carbon with emissions.		
Climate damages due to trade	Extends costs of economic activity captured in GPI to those outside of the jurisdiction's border, to account for broader impacts of imported goods.				

Pollution damages due to trade	Extends costs of economic activity captured in GPI to those outside of the jurisdiction's border, to account for broader impacts of imported goods.				
Social costs embodied in trade	Extends costs of economic activity captured in GPI to those outside of the jurisdiction's border, to account for broader impacts of imported goods.				
Depletion of natural capital (-DNK)	Could be justified as BEC approach; or justified as foresight impact on current utility (NEC).			Justified as the disutility generated by the depletion of natural capital for those who are willing to pay to prevent their loss.	
Non-renewable energy	Accounted for as the replacement cost of nonrenewable energy consumption.	*Cost of non-renewable energy resource depletion = replacement costs in electrical sector + replacement costs outside electrical sector* Utilized the same assumptions as Maryland for the replacement mix and costs (replaced fossil fuels in the electricity sector with a 50/50 mix of wind and solar energy, estimated to cost $0.0875 per kilowatt-hour based on Makhijani (2007), and biofuels for all other uses at $116 per barrel equivalent).	Valued as the investment expenditures need to meet climate goals.	Follows standard approach, valuing replacement cost for transportation with biofuels, and electricity with solar and wind.	
Groundwater	Accounted for as the replacement cost for groundwater depletion.			Utilizes USGS estimates for regional annual aquifer depletion rates over the last century converted to an acre feet per year basis coupled with the median replenishment costs available for aquifers in California	

				reported by Stanford.	
Soil erosion	Accounted for as the replacement cost for soil erosion.			Utilizes Natural Resource Conservation Service data on per acre erosion rates, USDA data on cultivated farmland, as well as urban land use erosion rates from EPA. Multiplies average current retail price for topsoil by erosion rate estimates.	
Land conversion	Wetlands, farmland, and forest coverage provide ecosystem services to be accounted for as losses when converted; alternatively, could be justified as economic tradeoff of conversion activities.	*Value of net <u>wetlands</u> change = (change in the number of acres) x (estimated wetland value per acre)* No studies of the economic value of wetlands have been conducted for Hawaiʻi . We therefore use the same valuation as Maryland ($1973 per acre per year beginning in 1950, increasing by 2% annually to reflect the fact that they are becoming scarcer). *Value of net <u>farmland</u> change = (number of acres farmland lost) x (estimated productivity per acre)* Utilizes 1998 GPI study value of $404 per acre, adjusted to Hawaiʻi's productivity, which is 1.8 times the national average. *Value of net <u>forest</u> change = (change in number of acres) x (estimated forest value per acre)* Utilized valuation of $1,690 per acre based on Koʻolau forest valuation.	Note: VdS does not include, but mentions its validity.	Utilizes NLCD data to build upon the traditional land conversion categories of forests, farmland, and wetlands, to include all natural land cover types. Rather than valuing these conversions in terms of ecosystem services that would otherwise exist, values them as the marginal economic tradeoff of the land conversion activities. Assumes a 50 year time horizon and a 3% discount rate in these calculations.	Add in coastal/marine change

		Not included, but proposed: *Value of net coral cover change = (number of acres change) x (estimated coral value per acre)* Submerged coastal systems not currently included in GPI; would require multi year data on coral coverage.			
Fisheries	Not in either study. Aspirational.				
Social costs (-SS)	Social costs of economic activity reduce overall welfare; some of these may already be accounted for in defensive expenditures.				
Homelessness	An undesirable social outcome largely of housing market failures.			Multiplies annual average homeless counts by $40,000 (Culhane, 2008 - an estimate for use of shelters, public services, health care etc. predominantly by homeless people). Cautions this includes some double counting with PP indicator.	
Underemployment	When people want to work more but the labor market does not provide opportunities, utility is lost.			Follows standard precedent for US GPIs (i.e. McGuire et al 2012).	
Commuting	This GPI indicator calculates both the direct and indirect expenses of commuting. The direct, or out-of-pocket expenses relate to the money spent to operate a vehicle or for fare on a bus or other public transportation. The indirect costs are associated with loss of time while commuting, time that could	*1) Direct costs of commuting by car = (number of workers commuting by single occupancy vehicle + 50% of the number of workers carpooling) x 30% of total VMT x cost per mile for vehicle use.* *2) Direct cost of commuting by public transit = number of*			

	have been spent on other, more enjoyable or productive activities.	*workers taking the bus x average fare per trip x number of trips (assuming round trip each day and 250 work days per year).* *3) Indirect cost of commuting representing lost time = average commuting time (across driving and public transit) x 2 (for round trip) x adjusted local wage rate*			
Crime	Crime thrusts negative social and economic impacts on individuals and households within each state. GPI studies focus on the impacts of crime to individuals and households, assuming that other costs, such as incarceration, are borne by the government.	*Cost of Crime = Number of each Crime * Victim Cost Estimate for each Crime* To calculate and account for the welfare of crime victims through trauma, fear, and physical damages, the US Department of Justice's estimates of damages were used. Each specific type of crime was multiplied by a set amount or "Victim Costs and Consequences" from the U.S. Department of Justice, calculated for both quality of life effects and property losses.		Follows standard precedent for US GPIs (i.e. McGuire et al 2012).	Not a defensive expense?
Family Breakdown				Included in -DEFR	
Lost Leisure Time	Lost leisure time has a welfare opportunity cost. Note: lost Leisure Time should not be included if benefits of workday leisure were already accounted for due to double counting.	*Cost of lost leisure time = Hawai'i average wage rate×total number of leisure hours lost* *Where;* *Total number of leisure hours lost = number of unconstrained workers in labor force × lost leisure time per unconstrained worker* *Number of unconstrained*		Included in +KH.	

		workers in labor force = 1-unemployment rate / 100 × state labor force *Lost leisure time per unconstrained worker = difference between current year work hours and base year 1969 work hours*			
Vehicle Crashes	Social costs from vehicle accidents can include property damage, lost household production, travel delay, etc. Standard economic measuring systems do not account for motor vehicle crashes as costs; in fact the side effects could be misconstrued as a positive economic gain.	*[(Number of Deaths from Motor Vehicle Crashes) x $1,024,000] + [(Number of Injuries from Motor Vehicle Crashes) x $36,000] + [(Property Damage Accidents) x $6,400] in 2000 USD* Cost estimates from National Safety Council (NSC) Injury Facts data.	Note: Vds includes this in DEFR indicator.	Follows standard precedent for US GPIs (i.e. McGuire et al 2012), *Number of Deaths from Motor Vehicle Crashes) x $1,024,000]* .	
Net capital growth (+/- NCG)	BEC/BCPA approach: net capital investment is justified as a proxy for the present discounted value of future consumption (Weitzman, 1976). Standard justification: It is important to maintain capital intact, i.e., keeping the capital-labor ratio constant from one year to the next, otherwise the capital is consumed as income in the present rather than invested for the future. GPI considers a positive increment in capital stock as an addition to GPI.	Net capital investment is the change in capital stock from the previous year minus the amount needed to maintain the same level of productivity, particularly if the labor force is growing.	VdS criticizes the previous approaches that take a 5-year rolling average and includes a growth requirement because that approach treats the flow as services from stock rather than changes in income. Motivation is sustainability rather than K:L ratio. Utilizes AMECO data to calculate the difference between capital stock in present and previous year, where current capital stock is calculated by the difference between gross fixed capital formation and the consumption of fixed capital to the previous year's net capital stock.		

Table A-2. Proposed modifications and/or additions to several key social indicators

Indicator	"As Is"	Limitations	Potential Modifications/ Auxiliary Indicators
Unpaid work	ATUS data on time on housework by state population over 15. Computed using average hourly wage of domestic/cleaning personal in state or average state wage.	Cost of care and cleaning does not reflect total value. Inherent limitations to the ability to monetize care work.	**Use and include satellite.** Use current indicator with average state wage (not domestic/cleaning wage) and supplement with satellite time-use studies.
Family Breakdown	State divorce rate. National average number of children per divorce. State households with children. National hours of TV. National cost of divorces and social cost of TV viewing.	Assumption that divorce is negative (compared to negative outcomes of violence, conflict in the home etc.) Assumption of negative impacts of tv consumption. Does not address true issues of concern which might be better framed as child welfare or the effects of late capitalistic work patterns on individual welfare and family wellbeing.	**Remove/reframe.** Future iterations could assess this in terms of the cost of demographic change and the impact of high dependency ratios (large populations of very young and elder populations on working age people).
Cost of crime	State crime numbers. National costs to victims by type of crime.	Will over-represent certain crimes that are more likely to be reported while under-representing others that tend to have low reporting levels (e.g. sexual assault). Some crimes not well accounted for (e.g. state crimes, corruption, white collar financial).	**Use, supplement and satellite account.** Supplement GPI with an indicator on the social cost of incarceration. Satellite accounts and writing could highlight issues in underreporting and spotlight the economic costs of particular crime classes (e.g. domestic or intimate partner violence).
Value of volunteer work	Constant national volunteer hours per year rate by state, population15 and	Value is likely much larger than what is reported through volunteer work survey	**Use and narrative account.** This indicator can be used along with a narrative account of the kinds of volunteer and

	over. Average hourly wage in state.	and through average hourly wages.	community work undertaken in a given locale.
Value of higher education*	Population of college educated in the state. National value of positive externalities from education.	This framing misses other areas of education investment and misses key distributional issues affecting education such as: segregation and exclusion/expulsion rates by race/ethnicity and disability inclusion metrics.	**Reframe.** This category of impact is placed within a new sphere, investment in “Public Goods.”
Services of streets and highways	US highways and streets. Ratio of State highway miles to National.	Somewhat irrelevant national metrics for Hawai’i. Additionally, this does not account for water transportation via waterways/ports.	**Reframe and narrative account.** This category of impact is placed within a new sphere, investment in “Public Goods.”A narrative investigation of “complete streets” efforts could be helpful for assessing the safety and value of transportation infrastructure.
Cost of commuting	State average travel time to work. American Community Survey numbers of commuters per state. Average hourly wage in state. State public fare revenues instead of entire operational cost of public transit. National cost per mile driven.	This metric has been reframed into the cost of leisure time. This will also miss some of the distributional issues, where some residents face particular commuting costs where infrastructure is inadequate to usage (e.g. O‘ahu west coast).	**Reframed.** This category of impact is placed within the area of disutility. Additionally, narrative accounts can highlight distributional issues.
Lost leisure time	State unemployment rate. State fully employed rate by constant national number of hours lost by fully employed. State average wage rate.	Not clear that the metric adequately captures leisure time issues, and cannot capture time poverty or distributional issues by gender and race in leisure time.	**Reframe.** Imputed as “value of leisure time during work hours.”
Cost of Road Accidents	State fatalities, injuries, property damage. National costs of fatalities, injuries, property damage.	Not clear why property damage should be considered together with injury and loss of life. May be double counted from healthcare costs.	**Use/reframe.**This could be used but shifted into the section on “Defensive/ Regrettable Expenditures.”

Appendix B Indicator data availability

Population

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Population- United States	Persons	Data: Population, Total for United States, Persons, Annual, Not Seasonally Adjusted from FRED https://fred.stlouisfed.org/series/POPTOTUSA647NWDB or use US Census data National Population Totals: 2010-2020	1960--2020
2.	Population- State of Hawaii	Persons	Data: Hawaii Data Book, Table 1.06-- RESIDENT POPULATION, BY COUNTY: 1940 TO 2019 http://dbedt.hawaii.gov/economic/databook/data_book_time_series/	1960-2020
3.	Ratio of Hawaii to U.S. by Population	%	Calculation: Population HI/Population USA (Line 2/Line 1); this variable is used in +PP and +KB/Water Infrastructure	--
4.	Total Population - State of Hawaii (Census data)	Persons	Data: US Census by state 2010-2019 found at https://www.census.gov/data/datasets/time-series/demo/popest/2010s-state-total.html	2010-2020
5.	Resident Population - State of Hawaii (Census data)	Persons	Data: This row uses a different U.S. Census dataset that distinguishes between resident and total population; see US Census Annual Estimates of the Resident Population for the United States, Regions, States, the District of Columbia, and Puerto Rico: April 1, 2010 to July 1, 2019; April 1, 2020; and July 1, 2020	2010-2020

CPI-U

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	CPI-U		Data: Bureau of Labor Statistics, Table 24: 'Historical CPI-U' or see BLS website CPI Database	1960-2020
2.	CPI-U, Base Year 2020	%	Calculation: CPI-U (Line 1) Divided by CPI-U 2020 (Line 1, Column Year 2020)	
3.	CPI-U, Base Year 2012	%	Calculation: CPI-U (Line 1) Divided by CPI-U 2012 (Line 1, Column Year 2012)	

Personal Consumption Expenditure (+PCE)

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Personal Income USA	Current USD, Billions	Data: BEA: NIPA Tables Database (UPDATED-2/22/2021); National Data, Table 2.1 "Personal Income and Its Disposition"; https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey	1960-2020
2.	Personal Consumption USA	Current USD, Billions	Data: BEA: NIPA Tables Database (UPDATED-2/22/2021); Table 2.4.5 "Personal Consumption Expenditures by Type of Product"; https://apps.bea.gov/iTable/iTable.cfm?ReqID=70&step=1#reqid=70&step=1&isuri=1; SAEXP1 Total personal consumption expenditures (PCE) by state 1/	1960-2020
3.	Personal Income Hawaii	Current USD, Billions	Data: BEA: SPI Tables Database (UPDATED-2/22/2021) https://apps.bea.gov/iTable/iTable.cfm?7001=1200&7002=1&7003=200&7004=naics&7005=101&7006=01000&isuri=1&reqid=70&step=10	1960-2020
4.	Ratio Consumption-Income USA	%	Calculation: Personal consumption USA/Personal income USA (Line 3/Line 2)	--
5.	Personal Consumption Hawaii (modeled)	Current USD, Billions	Calculation: Personal Income HI* Ratio consumption-income USA (Line 4* Line 5)	--
6a..	Hawaii Personal Consumption Expenditures (modeled)	2020 USD, Billions	Calculation: Personal Consumption Hawaii (modeled)/CPI-U (Line 6/CPI-U)	--

6b.	Hawaii Personal Consumption Expenditures (1997-2019)	Current USD, Billions	Data: Bureau of Economic Analysis (1997-2019); Regional Data, SAEXP1 Total personal consumption expenditures (PCE) by state 1/; https://apps.bea.gov/iTable/iTable.cfm?ReqID=70&step=1#reqid=70&step=1&isuri=1	1997-2020
6c.	Hawaii Personal Consumption Expenditures (1997-2019)	2020 USD, Billions	Calculation: Hawaii Personal Consumption Expenditures (1997-2019)/CPI-U (Line 6b/CPI-U)	--

Defensive & Regrettable Expenditures (-DEFR)

Food & Alcohol

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Food at home	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 27: Food and nonalcoholic beverages purchased for off-premises consumption	2000-2020
2.	Food out of home	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 82: Food Services	2000-2020
3.	Alcohol	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 28: Alcoholic beverages purchased for off-premises consumption	2000-2020
4.	Junk food from home (0%)	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000*Line 8	–
5.	Junk food out of home (11.3%)	2020 USD, Billions	Calculation: Line 2/CPI-U 2020/1000*Line 7	–
6.	Alcohol (25%)	2020 USD, Billions	Calculation: Line 3/CPI-U 2020/1000* Line 9	–
7.	% spending on fast food	%	Use 11.3% based on estimate that 11.3% of average adult calories from fast food ; CDC Caloric Intake from Fast Food Among Adults: United States, 2007–2010	–
8.	% spending on junk food at home	%	Use 0% as data currently lacks	–
9.	% spending on alcohol	%	Use 25%, following Talberth & Wesidorf (2017), Lawn (2005), and others in GPI literature.	–
10.	Total food & alcohol	2020 USD, Billions	Calculation: Line 1+Line 2+Line 3	–

Tobacco

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Tobacco	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 44: Tobacco and assumption that 100% of tobacco use is unsafe	2000-2020
2.	Tobacco	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000	--

Insurance & Financial Services

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Financial services	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 87: Financial Services	2000-2020
2.	Insurance	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 90: Insurance	2000-2020
3.	Financial services	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000	--
4.	Insurance	2020 USD, Billions	Calculation: Line 2/CPI-U 2020/1000	–
5.	Financial services & Insurance (100%)	2020 USD, Billions	Calculation: Line 3 + Line 4	–

Food Waste

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Estimated food waste, home (@ 25%)	%	Estimate of 25% wasted food at home from T&W 2017 based on Gunder (2012) for NRDC; using NRDC study as placeholder until more locally relevant % is found (refer to Luke & Leung (2015))	–
2.	Estimated food waste, outside the home (@ 19%)	%	Estimate of 19% wasted food outside of home from T&W 2017 based on Gunder (2012) for NRDC; using NRDC study as placeholder until more locally relevant % is found (refer to Luke & Leung (2015))	--
3.	Food at Home	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 27: Food and nonalcoholic beverages purchased for off-premises consumption	2000-2020
4.	Food Out	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 83: Purchased Meals and Beverages	2000-2020
5.	Food at Home	2020 USD, Billions	Calculation: Line3/CPI-U/1000 (to convert to US$2020, Billions) minus "junk food at home" (currently zero bc no data; see "Food & Alcohol BEA" tab) to avoid double counting	--
6.	Food Out - Junk Food	2020 USD, Billions	Calculation: Line4/CPI-U/1000 (to convert to US$2020, Billions) minus "junk food out" (see "Food & Alcohol BEA" tab) to avoid double counting	--
7.	Food Wasted at Home	2020 USD, Billions	Calculation: Line5*Line1	–
8.	Food Wasted Out	2020 USD, Billions	Calculation: Line6*Line2	--
9.	Total spending on wasted food (inside + outside home)	2020 USD, Billions	Calculation: Sum Line5 + Line 6	–

Household Pollution Abatement

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Cost of air pollution abatement	2020 USD, Billions	Data: Total cost of air pollution abatement for personal vehicles, 'Air Pollution' Tab, Line 19	2000-2020
2.	Cost of wastewater pollution abatement	2020 USD, Billions	Data: Total spending on wastewater pollution abatement, 'Wastewater Pollution Abatement' Tab, Line 8	2000-2020
3.	Cost of solid waste pollution abatement	2020 USD, Billions	Data: Total cost of solid waste management, 'SW Pollution Abatement' Tab, Line 5	2000-2020
4.	Total cost of personal pollution abatement (air + WW + SW)	2020 USD, Billions	Calculation: cost of air pollution abatement + wastewater abatement + solid waste abatement (Line 1 + Line 2 + Line 3)	--

Air Pollution Abatement

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	All vehicles registered	# of vehicles	Data: DBEDT Table 18.08; VEHICLE REGISTRATION, BY TYPE OF VEHICLE, ALL VEHICLES: 2018 https://files.hawaii.gov/dbedt/economic/databook/db2019/section18.pdf	2000-2019; *2020 extrapolated*
2.	Passenger vehicles registered	# of vehicles	Data: DBEDT Data Table 18.06; VEHICLE REGISTRATION, BY TYPE OF VEHICLE: 2008 TO 2018; https://files.hawaii.gov/dbedt/economic/databook/db2019/section18.pdf	2000-2019; *2020 extrapolated*
3.	Trucks, vans, pickups registered as passenger vehicles	# of vehicles	Data: DBEDT Data Table 18.06; VEHICLE REGISTRATION, BY TYPE OF VEHICLE: 2008 TO 2018; Vans, pickups, and other trucks under 6,500 lb. in personal use, legally classified as passenger vehicles, are included in the totals for trucks.; https://files.hawaii.gov/dbedt/economic/databook/db2019/section18.pdf	2000-2019; *2020 extrapolated*
4.	Number personal use vehicles registered (passenger vehicles + trucks)	# of vehicles	Calculation: Passenger vehicles registered Added to Trucks, vans, pickups registered as passenger vehicles (Line 2 + Line 3 to determine # of personal vehicles registered (cars + minivans + SUVs + pickup trucks, etc.)	--
5.	New passenger car and light truck (van) registrations (aka personal vehicles)	# of vehicles	Data: DBEDT Data Table 18.12; NEW PASSENGER CAR AND LIGHT TRUCK (VAN) REGISTRATIONS; 2019 https://files.hawaii.gov/dbedt/economic/databook/db2019/section18.pdf	2000-2019; *2020 extrapolated*
6.	New passenger vehicle registrations as % of total personal use vehicles	%	Calculation: Ratio of new personal vehicles to total personal vehicles registered (Line 5/Line 4)	--
7.	New passenger vehicle registrations as % of all registered vehicles	%	Calculation: Ratio of new personal vehicles to all vehicles registered (Line 5/Line 1)	--
8.	Cost of catalytic converter per new vehicle =	2020 USD	Data:150.30; Used value from previous GPI as cost (in 2000 USD) of $100 for a catalytic converter (following the 2004 study by Costanza et al.)	--
9.	Cost of air filter per new vehicle =	2020 USD	Data: 12.78; Used value from previous GPI as cost in 2000 USD of $8.50 for air filters for each new vehicle (as in the 2007 study by Bagstad and Ceroni); ideally need to determined local prices for air filters	--
10.	Cost of air pollution abatement (catalytic converter + air filter) per new vehicle =	2020 USD	Calculation:163.08; Air pollution abatement equipment + catalytic converter price + air filter price in 2020$ (Line 8 + Line 9)	--

11.	Cost of air pollution abatement equipment new personal vehicles	2020 USD	Calculation: # new personal vehicles registered * cost of air pollution abatement equipment (Line 5)(Line 10)	--
12.	Total annual VMT all vehicles	million of miles	Data: DBEDT Data Book Table 18.17; MOTOR VEHICLE FUEL CONSUMPTION AND VEHICLE MILES, 1996 TO 2020, AND BY COUNTY, 2019 AND 2020; Total annual VMT all vehicles https://files.hawaii.gov/dbedt/economic/databook/db2020/section18.pdf	2000-2020
13.	Annual VMT per vehicle	miles	Data: DBEDT Data Book Table 18.17; MOTOR VEHICLE FUEL CONSUMPTION AND VEHICLE MILES, 1996 TO 2020, AND BY COUNTY, 2019 AND 2020; Annual VMT per vehicle https://files.hawaii.gov/dbedt/economic/databook/db2020/section18.pdf	2000-2020
14.	Total annual VMT of personal vehicles	million of miles	Calculation: Annual VMT per vehicle * # personal vehicles registered (Line 13)(Line 4)	--
15.	Cost of replacement air filter	2020 USD	Data: 12.78; Used value from previous GPI as cost in 2000 USD of $8.50 for air filters for each new vehicle (as in the 2007 study by Bagstad and Ceroni)	--
16.	Replacement filters needed per year	# of filters	Calculation: Total annual VMT personal vehicles per year (Line 14) divided by 20,000 miles per air filter to determine # of air filters replaced per year	--
17.	Cost of air pollution abatement for maintenance	2020 USD	Calculation: Cost of replacement air filter (Line 15) * # filters replaced each year (Line 16)	--
18.	TOTAL COST of air pollution abatement for personal vehicles	2020 USD	Calculation: Cost of air pollution abatement equipment new personal vehicles +Cost of air pollution abatement for maintenance (Line 11 + Line 17)	--
19.	TOTAL COST of air pollution abatement for personal vehicles	2020 USD	Calculation: Total cost of air pollution abatement for personal vehicles/1,000,000,000 (Line 18/1,000,000,000)	--

Waste Water & Solid Waste Pollution Abatement

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Spending on Water Supply & Sanitation (WW) + Garbage & Trash (SW)	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 56: Water supply and sanitation (Note: also includes garbage and trash)	2000-2020
2.	Total Cost of WW and SW	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000	–

Medical & Legal Services

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Medical	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 40: Pharmaceutical and other medical products	2000-2020
2.	Health care	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 60: Health Care	2000-2020
3.	Legal	–	Not available from BEA	–
4.	Medical	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000	--
5.	Health care	2020 USD, Billions	Calculation: Line 2/CPI-U 2020/1000	–
6.	Medical Total	2020 USD, Billions	Calculation: Line 4 + Line 5	–

Energy Waste

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Residential spending on electricity	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 58: Electricity	2000-2020
2.	Residential spending on electricity	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000	–
3.	Energy efficiency potential	%	Data: Assumed economic potential as percentage (16% taken from T&W (2017) for Maryland use as placeholder until we can sub in Hawaii specific potential savings	--
4.	Unrealized savings from energy efficiency	2020 USD, Billions	Calculation: Line 2 * Line 3	--

Lotteries

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Gambling	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 79: Gambling	2000-2019
2.	Gambling	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000	–

Household Investments (-HI)

Household Repairs/Maintenance & Home Improvement

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Household repairs/maintenance & home improvement	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 107: Household Maintenance	2000-2020
2.	Savings, investment, & retirement	–	Not available from BEA	–
3.	Charitable giving	–	Not available from BEA	--
4.	Higher education	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 101: Higher Education	2000-2020
5..	Vocational education	Current USD, Millions	Data: BEA; Personal Consumption Expenditures by State/Personal consumption expenditures by type of product (SAPCE3) Hawaii; use Line Code 103: Commercial and Vocational Schools	2000-2020
6.	Household repairs/maintenance & home improvement	2020 USD, Billions	Calculation: Line 1/CPI-U 2020/1000	–
7.	Higher education	2020 USD, Billions	Calculation: Line 4/CPI-U 2020/1000	--
8.	Vocational education	2020 USD, Billions	Calculation: Line 5/CPI-U 2020/1000	–
9..	Total Household Investments	2020 USD, Billions	Calculation: Line 6 + Line 7 + Line 8	--

Consumer Durable Expenditures (-CDE)

Note: Items in gray may be removed in the future

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	National Consumer Durables Spending	Current USD, Billions	Data: BEA NIPA Table 2.3.5 (Accessed 03/17/2021); Line 'Durable Goods' https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey	2000-2020
2.	National Personal Income	Current USD, Billions	Data: From PCE Sheet: BEA: NIPA Tables Database	--
3.	Percentage of Income Spent on Durables in US	%	Calculation: National Consumer Durables Spending Divided by National Personal Income (Line 1/Line 2)	--
4.	Personal Income Hawaii	Current USD, Billions	Data: From PCE Sheet: BEA: SPI Tables Database	--
5a.	Consumer Durables Spending Hawaii (modeled)	Current USD, Billions	Calculation: Percentage of Income Spent on Durables in US Divided by Personal Income Hawaii (Line 3*Line 4)	--
5b.	Cost of Consumer Durable Expenditures in Hawaii (modeled)	2020 USD, Billions	Calculation: Line 5b Divided by CPI-U	--
6a.	Consumer Durables Spending Hawaii	Current USD, Billions	BEA Regional Data, Personal consumption expenditures (PCE) by state Table SAEXP1 Total personal consumption expenditures by major type of product; choose consumer durable expenditures	2000-2020
6b.	Consumer Durables Spending Hawaii	2020 USD, Billions	Calculation: Consumer Durable Spending in Hawaii (modeled) Divided by CPI-U, Base Year 2020 (Line 5a/'CPI-U' Tab)	--
6c.	Hawaii Consumer Durable Expenditures (modeled hindcast for 1992 to 1996 only)	2020 USD, Billions	Modeled for calculation of CDS and depreciation over 8 years (e.g., use modeled data from 1992 to 1996 and real data from 1997 to 1999 for calculation of depreciation in 2000)	--

Cost of Income Inequality (-INQ)

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Adjusted PCE (PCE-DEFR-HI-CDE)	2020 USD, Billions	Data: Values from Summary Tab (PCE-DEFR-HI-CDE)	2000-2020
2.	DMUI_Ratio (adjusted/unadjusted)	%	Calculation: DMUI Ratio calculated as the adjusted/adjusted income. See R markdown file for calculation	Interpolated 2007-2011; 2020
3.	Total adjustment (- implies to be subtracted from PCE)	2020 USD, Billions	Calculation: (Adjusted PCE (PCE-DEFR-HI-CDE)) - (Adjusted PCE (PCE-DEFR-HI-CDE) * DMUI_Ratio (adjusted/unadjusted) (Line 1 - (Line 1 * Line 2))	--

Public & Non-Profit Provision of Goods & Services (+PP)

Line Item	Variable	Units adjusted to 2020$	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Hawaii share of Federal gov't non-defense consumption expenditures & gross investment	Current USD, Millions	Data for Non Defense: Use Quarterly Gross domestic product (GDP) by state: Federal civilian (Line 84) in Table SQGDP2 Quarterly for Hawaii 2005-2020 (Millions of current dollars). From menu bar at the top of bea.gov, choose Data by Place-States and Territories-GDP by State (with Industry Detail)/Interactive Data/Interactive Table. Once in the BEA Interactive Data Tables for Regional Data and GDP and Personal Income, choose the option for Quarterly Gross domestic product (GDP) by state: Federal civilian (a subset of Government and Government enterprises) in Table SQGDP2 Quarterly for Hawaii 2005-2020 (Millions of current dollars). Download quarterly figures and calculate the annual values by taking the mean across the quarters for each year and convert from millions of current $ to billions of 2020$. Use linear trend to extrapolate values prior to 2005.	2005-2020; extrapolated for 2000-2005
1b.	Hawaii share of Federal gov't non-defense consumption expenditures & gross investment	2020 USD, Billions	Calculation: (Line 1a/CPI-U)/1000	–
2a.	Hawaii State & Local gov't consumption exp & gross invest	Current USD, Millions	Data for State and Local: Use Quarterly Gross domestic product (GDP) by state: State and local (Line 86) in Table SQGDP2 Quarterly for Hawaii 2005-2020 (Millions of current dollars). From menu bar at the top of bea.gov, choose Data by Place-States and Territories-GDP by State (with Industry Detail)/Interactive Data/Interactive Table. Once in the BEA Interactive Data Tables for Regional Data and GDP and Personal Income, choose the option for Quarterly Gross domestic product (GDP) by state: State and local (a subset of Government and Government enterprises) in Table SQGDP2 Quarterly for Hawaii 2005-2020. Download quarterly figures and calculate the annual values by taking the mean across the quarters for each year and convert from millions of current $ to billions of 2020$ Use linear trends to extrapolate values prior to 2005.	2005-2020; extrapolated for 2000-2005
2b.	Hawaii State & Local gov't consumption exp & gross invest	2020 USD, Billions	Calculation: (Line 2a/CPI-U)/1000	–
3a.	Hawaii NPISH from BEA Regional Dataset	Current USD, Millions	Data for Services of NPISHs: Final consumption expenditures of nonprofit institutions serving households (NPISHs) from BEA's regional datasets that now track NPISH by state in Table SAPCE4 1997-2020 Personal consumption expenditures (PCE) by state by function (in Millions of current dollars). If direct link does not work, you can use BEA interactive tables and choose Regional Data/GDP and Personal Income/Personal Consumption Expenditures by State/Personal consumption expenditures by function (SAPCE4) and select Hawaii, Final consumption expenditures of nonprofit institutions	2000-2020

			serving households (NPISHs), and years desired (Line code 132). Convert from millions of current $ to billions of 2020$. See also for reference DBEDT Data Table 13.37 Table 13.37-- PERSONAL CONSUMPTION EXPENDITURES, BY MAJOR TYPE OF PRODUCT: 2012 TO 2018 https://files.hawaii.gov/dbedt/economic/databook/db2019/section13.pdf	
3b.	Hawaii NPISH from BEA Regional Dataset	2020 USD, Billions	Calculation: (Line 3a/CPI-U)/1000	–
4.	Hawaii total share of public & non-profit goods and services	2020 USD, Billions	Line 1b + Line 2b + Line 3b	–

Services from Social/Human Capital (+KH)

College Graduates

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Hawaii Population	Persons	Data: From Population tab	--
1a.	Hawaii Population under 5	Persons	Data: DBEDT Economic Data Warehouse: Population by Age Table; https://dbedt.hawaii.gov/economic/datawarehouse/	2000-2020
1b.	Hawaii Population ages 5-9	Persons	Data: DBEDT Economic Data Warehouse: Population by Age Table; https://dbedt.hawaii.gov/economic/datawarehouse/	2000-2020
1c.	Hawaii Population ages 10-14	Persons	Data: DBEDT Economic Data Warehouse: Population by Age Table; https://dbedt.hawaii.gov/economic/datawarehouse/	2000-2020
1d.	Hawaii Population ages 15-19	Persons	Data: DBEDT Economic Data Warehouse: Population by Age Table; https://dbedt.hawaii.gov/economic/datawarehouse/	2000-2020
1e.	Hawaii Population ages 19-24	Persons	Data: DBEDT Economic Data Warehouse: Population by Age Table; https://dbedt.hawaii.gov/economic/datawarehouse/	2000-2020
2.	Hawaii Population over 25	Persons	Calculation: Hawaii Population-(sum of Population under 5-24) (Line 1-(sum of Line 1a to Line 1e))	--
3.	Hawaii Population over 25 w/ Bachelors Degree + as a percentage of the population	%	Calculation: Percentage of Hawaii Population over 25 w/ Bachelors Degree + (Line 2) Multiplied by Hawaii Population over 25 (Line 1a)	--
4.	Hawaii Population 25+ w/ a Bachelor Degree +	Persons	Calculation: Hawaii Population over 25 w/ Bachelors Degree Multiplied by Value per College Graduate (Line 3*Line 5)	--
5.	Value per College Graduate	2020 USD	Calculation: Value of College Graduates in Hawaii (Line 4a) Divided by 1,000,000,000	--
6.	Value of College Graduates	2020 USD	Calculation: Hawaii Population 25+ w/ a Bachelor Degree Multiplied by Value per College Graduate (Line 4*Line 5)	2020
7.	Value of College Graduates	2020 USD, Billions	Calculation: Value of College Graduates/1,000,000,000 (Line 6) converted to billion 2020$	--

Manufacturing Jobs

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Hawaii Number of Manufacturing Jobs	Jobs	Data: Using BLS Data Tools, choose Top Picks, One Screen, …/Employment/ Employment, Hours, and Earnings – State and Metro Area (Current Employment Statistics – CES)/One Screen/Hawaii/30 Manufacturing/Seasonally adjusted/Add to Selection/Get data Alternative data source = Hirenet Hawaii Job Count by Industry; https://www.hirenethawaii.com/gsipub/index.asp?docid=727	2000-2020
2.	Value per Manufacturing Job	2020 USD	Data: $11,236.00; Value per job of $10,000 (2012$) from T&W (2017) updated to $11,236 in 2020$	–
3.	Value of Manufacturing Jobs in Hawaii	2020 USD	Calculation: Hawaii Number of Manufacturing Jobs Multiplied by Value per Manufacturing Job (Line 1*Line 2)	–
4.	Value of Manufacturing Jobs in Hawaii	2020 USD, Billions	Calculation: Value of Manufacturing Jobs in Hawaii (Line 3) Divided by 1,000,000,000	–

Green Jobs (not included in GPI calculation due to data gaps)

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	US Number of Green Jobs	Jobs	Data: BLS Green Jobs Overview 2013; https://www.bls.gov/opub/mlr/2013/01/art1full.pdf	2011
2.	Hawaii Number of Green Jobs	Jobs	Data: Hawaii's Green Workforce Baseline Assessment DLIR (2010) https://energy.hawaii.gov/wp-content/uploads/2011/10/HawaiisGreenWorkforce_BaselineAssessment.pdf	2010
3.	Value of Green Jobs	2012 USD	Data: Value per job of $100,000 (2012$) from T&W (2017) updated to $11,236 in 2020$	--
4.	Value of Green Jobs in Hawaii	2020 USD, Billions	Calculation: Value of Manufacturing Jobs in Hawaii (Line 3) Divided by 1,000,000,000	N/A

Unpaid Work

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	National Average Hours Spent on Housework	hours per day	Data: ATUS; (national) for years 2003 to present in Table A-1 from line entitled "Household activities"; http://www.bls.gov/tus/tables.htm	2003-2019, *2000-2002 & 2020 extrapolated*
2.	National Average Hours Spent on Caregiving Nonhousehold Members	hours per day	Data: ATUS; (national) for years 2003 to present;from line entitled "Caring for and helping household members" in Table A-1; http://www.bls.gov/tus/tables.htm	2003-2019, *2000-2002 & 2020 extrapolated*
3.	Sum of National Average Hours Spent on Caregiving + Housework	hours per day	Calculation: National Average Hours Spent on Housework + National Average Hours Spent on Caregiving Nonhousehold Members (Line 1 + Line 2)	--
4.	Annual Hours Spent on Caregiving + Housework	annual hours per person	Calculation: Line 3 *365 days	--
5.	Hawaii Hourly Wage For Housekeepers & Cleaners	current USD	Data: BLS; Occupational Employment and Wage Statistics By State; MEDIAN; https://www.bls.gov/oes/tables.htm and see State Occupational Employment and Wage Estimates for Hawaii Maids and Housekeeping Cleaners: Occupational Code: 37-2012	2000-2020
6a.	Hawaii Population Over 15	persons	Calculation: Total HI Population - Population under 15 (Line from Population Tab - ALL Row 6b through 6d)	--
6b.	Hawaii Population under 5	persons	Data: DBEDT Datatables; Table 1.27-- RESIDENT POPULATION, BY AGE AND SEX: 2000 AND 2010; https://files.hawaii.gov/dbedt/economic/databook/2019-individual/01/012719.pdf	2000-2020
6c.	Hawaii Population ages 5-9	persons	Data: ATUS (national) for years 2003 to present in Table A-1 from line entitled "Household activities" see http://www.bls.gov/tus/tables.htm	2000-2020
6d.	Hawaii Population ages 10-14	persons	Data: ATUS (national) for years 2003 to present;from line entitled "Caring for and helping household members" in Table A-1 see http://www.bls.gov/tus/tables.htm	2000-2020
7.	Value of Housework per person per year	current USD	Calculation: Annual Hours Spent on Caregiving + Housework * Hawaii Hourly Wage For Housekeepers & Cleaners (Line 4 * Line 5)	--
8a.	Value of Housework in Hawaii	current USD, billions	Calculation: (Value of Housework per person per year/ Hawaii Population Over 15)/1,000,000,000 = (Line 7/Line 6a)/1,000,000,000	--
8b.	Value of Housework in Hawaii	2020 USD, Billions	Calculation:Value of Housework in Hawaii/CPU-U (Row 8a/CPI-U)	--
9.	Hawaii Total Annual Hours	Hours	Data: 2002-2015: View Data on "Hawaii CNCS Open Data" at data.americorps.gov;	2002-2015; 2016-2020;

	Volunteering		2016-2020: "Volunteering in America- State Data" at data.americorps.gov	*2000-2001 extrapolated*
10.	Dollar Value of a Volunteer Hour in Hawaii	current USD	Data: Value of volunteer time by state taken from Independent Sector; https://independentsector.org/wp-content/uploads/2018/04/Value-of-Volunteer-Time-by-State-2001-2020.pdf	2001-2020; *2000 extrapolated*
11a.	Value of Volunteer Work in Hawaii	current USD, billions	Calculation: Hawaii Total Annual Hours Volunteering Multiplied by Dollar Value of a Volunteer Hour in Hawaii/1,000,000,000 (Line 9 * Line 10)/1,000,000,000	--
11b.	Value of Volunteer Work in Hawaii	2020 USD, Billions	Calculation: Value of Volunteer Work in Hawaii/CPI-U (Line 11a / CPI-U)	--
12.	Value of Unpaid Work in Hawaii	2020 USD, Billions	Calculation: Value of Housework in Hawaii + Value of Volunteer Work in Hawaii (Line 8b + Line 11b)	--

Leisure

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	National Average Leisure Hours Per Workday	Hours per Day	Data: ATUS Table 11A. Time spent in leisure and sports activities for the civilian population by selected characteristics, annual averages, all days of week (Select Total & Years 2003-2019) https://www.bls.gov/webapps/legacy/tustab11a.htm	2003-2019; *2000-2002 and 2020 extrapolated*
2.	Hawaii Labor Force	Persons	Data: DBEDT Data Table 12.06-- EMPLOYMENT STATUS OF THE CIVILIAN LABOR FORCE: ANNUAL AVERAGE, 1990 TO 2020 see also BLS local area unemployment statistics (LAUS) https://data.bls.gov/pdq/SurveyOutputServlet	2000-2020
3.	Total Leisure Hours per year among employed workers in Hawaii	Hours per Year	Calculation: Line 1 * Line 2 * 5 days / week * 52 weeks/year	--
4a.	Hawaii Post-Tax Median Hourly Wage	Current USD	Data: "BLS Occupational Employment and Wage Statistics for Hawaii available for years 1998, 2016-2020 can be found at https://www.bls.gov/oes/2020/may/oes_hi.htm#00-0000"; Historical data for 2001-2015 available by downloading Excel files by state and year, and searching for median hourly wage for "all occupations" within the state at https://www.bls.gov/oes/tables.htm	2001-2020; *2000 extrapolated*
4b.	Hawaii Post-Tax Median Wage	2020 USD	Calculation: Hawaii Post-Tax Median Hourly Wage/CPI-U (Line 4a/CPI-U)	--
5.	Value of Leisure Time Per Year	2020 USD, Billions	Calculation:Total Leisure Hours per year among employed workers in Hawaii Multiplied by Hawaii Post-Tax Median Wage/1,000,000,000 = (Line 3 * Line 4b)/1,000,000,000	--

Internet

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	U.S. Total Households	Households	Data: Census Bureau- Historical Households Tables; HH-1 "Households by Type: 1940-Present"	2000-2020
2.	Hawaii Households	Households	Data: 2005-Present: DBEDT American Community Survey 1-Year Estimates; 2001-2004: DBEDT 2005 State of Hawaii Databook Table 1.49; Pre 2001: DBEDT 2001 State of Hawaii Databook Table 1.41 & 1.42	2000-2019; *2020 extrapolated*
3.	U.S Total Households w/ Home Internet Access	%	Data: % of US households w/ internet subscription; https://www.statista.com/statistics/189349/us-households-home-internet-connection-subscription/	2000-2019; *2020 extrapolated*
4.	Hawaii Households w/ Home Internet Access	Households	Calculation: Hawaii Households Multiplied by % of U.S Total Households w/ Home Internet Access (Line 2* Line 3)	--
5.	Hawaii Population (3+ years) w/ Home Internet Access	Persons	Calculation: Hawaii Households w/ Home Internet Access Multiplied by # People per Household in Hawaii (Line 4 * Line 6)	--
6.	# People per Household in Hawaii	People/Household	Data: Census Bureau QuickFacts, 3.00 people per household in Hawaii; https://www.census.gov/quickfacts/fact/table/HI,US/HCN010212	–
7.	Value of Internet in Hawaii	2020 USD	Data: $591 (in 2020$) based on the mean of two estimates for consumer surplus of free services per user per year from The Economist (2013) and Brynjolfsson & Oh (2012) converted to 2020 USD	--
8.	Annual Value of Internet in Hawaii	2020 USD	Calculation: Hawaii Population (3+ years) w/ Home Internet Access Multiplied by Value of Internet in Hawaii (Line 5 * Line 7)	--
9.	Annual Value of Internet in Hawaii	2020 USD, Billions	Calculation: Annual Value of Internet in Hawaii/1,000,000,000 (Line 8/1000000000)	--

Services from Consumer Durables (+CDS)

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Consumer Durables Spending Hawaii (Modeled)	2020 USD, Billions	Data: From CDE Tab in worksheet (modeled pre-1997)	1992-1996
1b.	Consumer Durables Spending Hawaii (BEA)	2020 USD, Billions	Data: From CDE Tab in worksheet (BEA data post 1997); relies on Regional Data from US BEA Table SAPCE1 Personal consumption expenditures (PCE) by major type of product: Total personal consumption expenditures: Durable goods (Millions of current dollars) from 1997-2020	1997-2020
2.	Depreciated past stock value	2020 USD, Billions	Calculation: Value of net stock of consumer durables at the end of the year; sum of the remaining stock from each of the last 8 years after yearly depreciation	--
3.	Depreciation factor	%	Data: Depreciation factor using 12.5% per year, based on linear depreciation with 8-year product life; follows Daly & Cobb (1994) and GPI literature thereafter	--
4.	Interest rate	%	Data: Interest rate assumed as interest rate on the stock of capital at 7.5%; follows Daly & Cobb (1994) and GPI literature thereafter	--
5.	Service (depreciation + interest rate)	%	Calculation: Service from consumer durables assumed to be 20% (sum of depreciation and interest rates = Line 3 + Line 4)	--
6.	Services from consumer durables	2020 USD, Billions	Calculation: Depreciated past stock value Multiplied by Service (depreciation + interest rate) Value of services from consumer durable stock (Line 2*Line 5)	--

Services Built Capital (+KB)

Transportation

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	US Current Net Depreciation of Transportation Stock Values	Current USD, Billions	Data: NIPA Table 7.1 Current-Cost Net Stock of Government Fixed Assets Line 12 Transportation	2000-2020
2.	Ratio of Hawaii to US population	%	Data: See Population tab	--
3.	Hawaii Share of US Current Net Depreciation of Transportation Stock Values	Current USD, Billions	Calculation: US Current Net Depreciation of Transportation Stock Values Multiplied by Ratio of Hawaii to US population (Line 1 * Line 2); uses the ratio of Hawaii to national population to scale down national spending to subnational level in the absence of state specific datasets	--
4.	US Current Net of Depreciation Highways & Streets Stock Values	Current USD, Billions	Data: NIPA Table 7.1 Current-Cost Net Stock of Government Fixed Assets Line 14 Highways & Streets	2000-2020
5a.	US Total Mileage of Highways & Roads	Miles	Data: Bureau of Transportation Statistics, Public Road and Street Mileage in the United States by Type of Surface; https://www.bts.gov/content/public-road-and-street-mileage-united-states-type-surfacea	2000-2020
5b.	Hawaii Total Mileage of Highways & Roads	Miles	Data: DBEDT Databook Table 1802: Length of Streets and Highways under Transportation in DBEDT Data Book throughout the years see http://dbedt.hawaii.gov/economic/databook/	2000-2020
5c.	Ratio of Hawaii to US Miles of Highways & Roads	%	Calculation: Ratio of Hawaii Total Mileage of Highways & Roads/US Total Mileage of Highways & Roads (Line 5b/Line 5a)	--
6.	Hawaii Share of Current Net of Depreciation Highways & Streets Stock Values	Current USD, Billions	Calculation:Scale down US total miles to Hawaii by multiplying total US miles by the ratio of Hawaii to US total miles; Line 4 *Line 5c	--
7.	Total Transportation Stock + Hwys & Streets Stock	Current USD, Billions	Calculation: Line 3 + Line 6; sum of transportation stock and miles of highway/roads attributed to Hawaii	--
8.	Portion not used for commuting (less 25% of services used for commuting to avoid double counting)	Current USD, Billions	Calculation: Line 7 * 75%; From Berik & Gaddis (2011) and past GPI studies, assumes that 25% of the infrastructure provides service for commuting; so to avoid double counting with the Commuting indicator, only use 75% of the stock for services other than commuting	--
9.	Annual Estimate for Services (2.5% depreciation + 7.5% interest)	%	Data: From Berik & Gaddis (2011) and past GPI studies that estimate the annual services that flow from the stock of transportation per year by using a factor of 10% = a depreciation rate of 2.5% plus an average interest rate of 7.5%	--

10.	Total value of Services from Transportation	Current USD, Billions	Calculation: Line 8 * Line 9; the portion not used for commuting * annual estimate for services of that stock	--
11.	Total value of Services from Transportation	2020 USD, Billions	Calculation: Total value of Services from Transportation/CPI-U (Line 10/CPI-U) to convert to 2020$	--

Water Infrastructure

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	US Current-Cost Net Stock Water Infrastructure	Current USD, Billions	Data: NIPA National Data Fixed Assets Accounts Table 7.1 Current-Cost Net Stock of Government Fixed Assets, Line 69 Water Infrastructure (water infrastructure listed under State and Local Structures)	2000-2020
2.	Ratio of Hawaii to US population		Data: From Population tab; uses the ratio of Hawaii to national population to scale down national spending to subnational level in the absence of state specific datasets	--
3.	Hawaii Current-Cost Net Stock Water Infrastructure (modeled)	Current USD, Billions	Calculation: National Current Net Depreciation of Water Infrastructure Stock Values Multiplied by Ratio of Hawaii to US population (Line 1 * Line 2)	--
4.	Annual Estimate for Services	%	Data: 10% following Berik & Gaddis (2011) and others; annual estimate of services combines a 2.5% depreciation rate + 7.5% avg interest rate/time value of money	–
5.	Services of Water Infrastructure Stocks	Current USD, Billions	Calculation: Hawaii Current Net Depreciation of Water Infrastructure Stock Values Multiplied by Annual Estimate for Services (Line 3 * Line 4)	--
6.	Value of Services from Water Infrastructure	2020 USD, Billions	Calculation: Services of Water Infrastructure Stocks/CPI-U (Line 5/CPI-U)	--

Household Improvements

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Spending on household improvements	2020 USD, Billions	Data: Taken from HI (Household investments) tab in worksheet; here household improvements only includes HH repairs and improvements	2000-2020
2.	Depreciated value of stock at end of year	2020 USD, Billions	Calculation: Sum of past 8 years of expenditures depreciated by 12.5% annually (assumes an 8-year investment lifespan)	--
3.	Depreciation rate	%	Data: Depreciation factor using 12.5% per year, based on linear depreciation with 8-year product life; follows Daly & Cobb (1994) and GPI literature thereafter	--
4.	Interest rate	%	Data: Interest rate assumed as interest rate on the stock of capital at 7.5%; follows Daly & Cobb (1994) and GPI literature thereafter	--
5.	Annual Estimate for Services	%	Data: Service from consumer durables assumed to be 20% (sum of depreciation and interest rates = Line 3 + Line 4)	--
6.	Value of Annual Services from Household Improvements	2020 USD, Billions	Data: Depreciated value of stock at end of year multiplied by Annual Estimate for Services (Line 2*Line 5) HI (only HH repairs and improvements)	--

Services Protected Areas (+KN)

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
CCAP1	Unclassified	hectares	Step 1: use the Protected Areas Database PAD-US (from the USGS GAP database) to identify protected areas with GAP status 1 and 2 protection only in Hawaii; PAD reports from 2016, 2018, 2020, although we only use 2016 as later reports are the same. Step 2: identify the types of land cover that overlay the protected areas for Hawaii in km2 per ecosystem category in CCAP1-CCAP22 (No CCAP23-25 in Hawaii) Step 3: cross reference CCAP categories with ESVD biome categories to find the most relevant and applicable overlaps Step 4: locate relevant ecosystem (ES) value in 2020USD/ha/year; convert km2 in Step 2 to hectares and multiply by ESVD value found in Step 3; ESVD values are from Summary Values tab, the Grand Total (biome) less provisioning services (i.e., subtracted out food, water, raw materials, genetic resources, medicinal resources, & ornamental resources); in 2020$/ha/year Step 5: Because we only have only two years of CCAP data (2005, 2010) and one year of PAD (2016), we assume that the total area designated as protected or the total area under each category has remained relatively constant throughout the entire time period. So for those years in which no CCAP data are available (2000-2004; 2006-2009; and 2011-2020) we assume 2005 levels for 2000-2004, interpolate between 2005 and 2010, and assume 2010 levels for years 2011-2020. Step 6: We value this change in land cover by the non-provisioning value for that land cover in the ESVD. Specifically, we calculate the NPV of each land cover type.	2016 (PAD) 2005, 2010/2011 (CCAP)
CCAP2	High intensity developed	hectares		
CCAP5	Open space developed	hectares		
	Total developed	2020 USD/Year		
CCAP6	Cultivated land	hectares		
CCAP7	Pasture/hay	hectares		
	Total cultivated	2020 USD/Year		
CCAP8	Grassland	hectares		
	Total grassland	2020 USD/Year		
CCAP10	Evergreen forest	hectares		
	Total tropical forest			
CCAP12	Shrub/scrub	hectares		
	Shrub/scrub	2020 USD/Year		
CCAP13	Palustrine forested wetlands	hectares		
CCAP14	Palustrine scrub/shrub wetlands	hectares		
CCAP15	Palustrine emerging wetlands	hectares		
CCAP22	Palustrine aquatic bed	hectares		
	Palustrine wetlands (total)	2020 USD/Year		
CCAP16	Estuarine forested wetlands	hectares		
CCAP17	Estuarine scrub/shrub wetlands	hectares		
CCAP18	Estuarine emerging wetlands	hectares		

CCAP19	Unconsolidated shore	hectares		
	Total wetlands + shore			
CCAP20	Barren land	hectares		
	Total desert			
CCAP21	Open water	hectares		
	Total open water			
	TOTAL services from protected areas	2020 USD/Year		
	TOTAL services from protected areas	2020 USD, Billions		

Local Pollution Costs (-POL)

Air

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Annual emissions NOx	Tons per Year	Data: From National Emissions Inventory from years 2008, 2011, 2014, 2017 found at: https://www.epa.gov/air-emissions-inventories/2008-national-emissions-inventory-nei-data	2008, 2011, 2017
1b.	NOx per capita	Tons per Capita	Data: Pollutant emission estimates in between NEI reporting years adjusted for population change as per Berik & Gaddis (2011); use NEI data in given years to find pollutant per capita and then multiply by population in years for which NEI data are not reported to estimate annual emissions of that pollutant	2000-2020; excluding 2008, 2011, 2014, 2017
1c.	Marginal damages NOx	2020 USD per Ton	Data: Marginal damages in 2002$ for air pollutant (NOx, SO2, PM2.5) from Table 3 (urban) in Muller and Mendelsohn (2007) converted to 2020$	--
1d.	Cost of NOx emissions	2020 USD	Calculation: Annual emissions NOx * Marginal damages NOx (Line 1a * 1c)	--
2a.	Annual emissions SO2	Tons per Year	Data: From National Emissions Inventory from years 2008, 2011, 2014, 2017 found at: https://www.epa.gov/air-emissions-inventories/2008-national-emissions-inventory-nei-data	2008, 2011, 2017
2b.	SO2 per capita	Tons per Capita	Data: Pollutant emission estimates in between NEI reporting years adjusted for population change as per Berik & Gaddis (2011); use NEI data in given years to find pollutant per capita and then multiply by population in years for which NEI data are not reported to estimate annual emissions of that pollutant	2000-2020; excluding 2008, 2011, 2014, 2017
2c.	Marginal damages SO2	2020 USD per Ton	Data: Marginal damages in 2002$ for air pollutant (NOx, SO2, PM2.5) from Table 3 (urban) in Muller and Mendelsohn (2007) converted to 2020$	--
2d.	Cost of SO2 emissions	2020 USD	Calculation: SO2 per capita * Marginal damages SO2 (Line 2a * 2c)	
3a.	Annual emissions PM2.5	Tons per Year	Data: From National Emissions Inventory from years 2008, 2011, 2014, 2017 found at: https://www.epa.gov/air-emissions-inventories/2008-national-emissions-inventory-nei-data	2008, 2011, 2017
3b.	PM2.5 per capita	Tons per Capita	Data: Pollutant emission estimates in between NEI reporting years adjusted for population change as per Berik & Gaddis (2011); use NEI data in given years to find pollutant per capita and then multiply by population in years for which NEI data are not reported to estimate annual emissions of that pollutant	2000-2020; excluding 2008, 2011, 2014, 2017

3c.	Marginal damages PM2.5	2020 USD per Ton	Data: Marginal damages in 2002$ for air pollutant (NOx, SO2, PM2.5) from Table 3 (urban) in Muller and Mendelsohn (2007) converted to 2020$	--
3d.	Cost of PM2.5 emissions	2020 USD	Calculation: Annual emissions PM2.5 * Marginal damages PM2.5 (Line 3a * 3c)	--
4.	Total cost of emissions	2020 USD	Calculation: Marginal damages NOx + Marginal damages SO2 + Marginal damages PM2.5 (Line 1c + 2c + 3c)	--
5.	TOTAL cost of emissions	2020 USD, Billions	Calculation: Total cost of emissions converted to billions 2020$ (Line 4 converted to billions 2020$)	--

Water

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Total area at high and very high risk	ha	Data: Based on National Fish Habitat Risk Assessment http://assessment.fishhabitat.org/#578a9a4ae4b0c1aacab89777/578a9a1be4b0c1aacab896d6; See Appendix water pollution sheet.	2010
2.	Value of lost ecosystem services	US$, billions	Data: Based on ESVD values for closest land cover. See Appendix water pollution sheet.	2010

Noise

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Total annual VMT all vehicles Hawaii	millions of miles	Data: VMTs annual for Hawaii found in DBEDT Data Table 18.17; https://files.hawaii.gov/dbedt/economic/databook/2019-individual/18/181719.pdf	2000-2020
2.	Cost of noise pollution per VMT	2020 USD/VMT	Figure from FHA 1997 study of noise cost per VMT = .003 USD/VMT in 2007$ converts to .00381 USD/VMT in 2020$ (average across all vehicle types)	–
3.	Total cost of noise pollution Hawaii	2020 USD	Calculation: Total annual VMT all vehicles Hawaii * Cost of noise pollution per VMT (Line 1 converted to miles (from millions of miles) * Line 2)	--
4.	Total cost of noise pollution Hawaii	2020 USD, Billions	Calculation: Convert total cost of noise pollution Hawaii to billions 2020$ (Line 3)	--

Solid Waste

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Volume of municipal solid waste (MSW) in Hawaii	tons/year	Data: DBEDT 2020 Data Book: Table 5.32-- SOLID WASTE RECYCLED IN HAWAII: 2001 TO 2020; see also Hawaii DOH OSWM Annual Reports; https://health.hawaii.gov/shwb/solid-waste/ the 2021 report with 2020 data; https://health.hawaii.gov/shwb/files/2021/03/2021-OSWM-Annual-Report-Amended.pdf	2001-2020; *2000 estimated*
2.	MSW externalities per ton	2020 USD/ton	Data: $21.71 in 2020$; T&W (2017) introduced adjustments for the external cost of solid waste ($19.26/ton in 2012$) based on Kinnaman (2009).	--
3.	Total cost of MSW externalities	2020 USD	Calculation: Volume of MSW in Hawaii * MSW externalities per ton (Line 1 * Line 2)	--
4.	Total cost of MSW externalities	2020 USD, Billions	Convert Line 3 to billions USD 2020	–

Greenhouse Gasses

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Coal consumption	Billion Btu	Data: EIA State Energy Systems Database (SEDS) data to determine amount of coal, natural gas, petroleum, and wood and waste consumed (reported in billion BTUs) for Hawaii, 1960-2019; https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI#StatisticsIndicators	2000-2019; *2020 extrapolated*
2.	Natural gas consumption	Billion Btu	Data: EIA State Energy Systems Database (SEDS) data to determine amount of coal, natural gas, petroleum, and wood and waste consumed (reported in billion BTUs) for Hawaii, 1960-2019; https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI#StatisticsIndicators	2000-2019; *2020 extrapolated*
3.	Petroleum consumption	Billion Btu	Data: EIA State Energy Systems Database (SEDS) data to determine amount of coal, natural gas, petroleum, and wood and waste consumed (reported in billion BTUs) for Hawaii, 1960-2019; https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI#StatisticsIndicators	2000-2019; *2020 extrapolated*
4.	Nuclear	Billion Btu	Data: EIA State Energy Systems Database (SEDS) data to determine amount of coal, natural gas, petroleum, and wood and waste consumed (reported in billion BTUs) for Hawaii, 1960-2019; https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI#StatisticsIndicators	2000-2019; *2020 extrapolated*
5.	Biomass (wood & waste)	Billion Btu	Data: EIA State Energy Systems Database (SEDS) data to determine amount of coal, natural gas, petroleum, and wood and waste consumed (reported in billion BTUs) for Hawaii, 1960-2019; https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI#StatisticsIndicators	2000-2019; *2020 extrapolated*
6a.	Coal	lbs CO2/million BTU	Data: EIA; conversion factors to change billion BTUs to tons CO2 emissions based on carbon equivalence rates from EIA US EIA conversion calculators https://www.eia.gov/energyexplained/units-and-calculators/energy-conversion-calculators.php https://www.eia.gov/tools/faqs/faq.php?id=73&t=11	--
6b.	Coal	metric ton CO2/billion BTU	Calculation: multiply lbs CO2/million BTU by a conversion factor of .4535925 to convert to metric tons per billion BTU (using 1 ton = .097185 metric ton)	--
6c.	Coal	metric tons of CO2	Calculation: For each fuel, multiply billions of BTU (Line 1, 2, etc.) for each fuel by conversion factor (6b, 7b, etc.) to calculate metric tons of CO2 per fuel type	--

7a.	Natural gas	lbs CO2/million BTU	Data: EIA; conversion factors to change billion BTUs to tons CO2 emissions based on carbon equivalence rates from EIA US EIA conversion calculators https://www.eia.gov/energyexplained/units-and-calculators/energy-conversion-calculators.php https://www.eia.gov/tools/faqs/faq.php?id=73&t=11	--
7b.	Natural gas	metric ton CO2/billion BTU	Calculation: multiply lbs CO2/million BTU by a conversion factor of .4535925 to convert to metric tons per billion BTU (using 1 ton = .097185 metric ton)	--
7c.	Natural gas	metric tons of CO2	Calculation: For each fuel, multiply billions of BTU (Line 1, 2, etc.) for each fuel by conversion factor (6b, 7b, etc.) to calculate metric tons of CO2 per fuel type	--
8a.	Petroleum	lbs CO2/million BTU	Data: EIA; conversion factors to change billion BTUs to tons CO2 emissions based on carbon equivalence rates from EIA US EIA conversion calculators https://www.eia.gov/energyexplained/units-and-calculators/energy-conversion-calculators.php https://www.eia.gov/tools/faqs/faq.php?id=73&t=11	--
8b.	Petroleum	metric ton CO2/billion BTU	Calculation: multiply lbs CO2/million BTU by a conversion factor of .4535925 to convert to metric tons per billion BTU (using 1 ton = .097185 metric ton)	--
8c.	Petroleum	metric tons of CO2	Calculation: For each fuel, multiply billions of BTU (Line 1, 2, etc.) for each fuel by conversion factor (6b, 7b, etc.) to calculate metric tons of CO2 per fuel type	--
9a.	Biomass	lbs CO2/million BTU	Data: EIA; conversion factors to change billion BTUs to tons CO2 emissions based on carbon equivalence rates from EIA US EIA conversion calculators https://www.eia.gov/energyexplained/units-and-calculators/energy-conversion-calculators.php https://www.eia.gov/tools/faqs/faq.php?id=73&t=11	--
9b.	Biomass	metric ton CO2/billion BTU	Calculation: multiply lbs CO2/million BTU by a conversion factor of .4535925 to convert to metric tons per billion BTU (using 1 ton = .097185 metric ton)	--
9c.	Biomass	metric tons of CO2	Calculation: For each fuel, multiply billions of BTU (Line 1, 2, etc.) for each fuel by conversion factor (6b, 7b, etc.) to calculate metric tons of CO2 per fuel type	--
10.	Total tons of CO2 across fuels	metric tons of CO2	Calculation: Sum across all fuels. (Line 6c + Line 7c + Line 8c + Line 9c)	--

11a.	Social Cost of Carbon (SCC)	USD 2000/ton C	Calculation: using Tol (2005) value for Social Cost of Carbon of $93 per ton carbon (tC) in 2004 USD, converted to $ per ton CO2, and then inflated to 2020 USD.	--
11b.	Social Cost of Carbon (SCC)	2000 USD/ton CO2	Calculation: using Tol (2005) value for Social Cost of Carbon of $93 per ton carbon (tC) in 2004 USD, converted to $ per ton CO2, and then inflated to 2020 USD.	--
11c.	Social Cost of Carbon (SCC)	2000 USD/ton CO2	Calculation: using Tol (2005) value for Social Cost of Carbon of $93 per ton carbon (tC) in 2004 USD, converted to $ per ton CO2, and then inflated to 2020 USD.	--
12a.	Cost of GHG emission from Hawaii	2020 USD	Calculation: Total tons of CO2 across fuels Multiplied by Social Cost of Carbon (SCC)(38.82 for 2020$) (Line 10*Line 11c)	--
12b.	Cost of GHG emission from Hawaii	2020 USD, Billions	Calculation: Cost of GHG emission from Hawaii Divided by 1,000,000,000 (Line 12a/1,000,000,000)	--

Depletion of Natural Capital (-DNK)

Non-Renewable Energy

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Total Coal Consumption in Hawaii	Trillion BTU per Year	Data: US EIA SED Hawaii (2019) Table CT2. Primary Energy Consumption Estimates, Selected Years, 1960-2019, Hawaii for Coal, Natural Gas, Petroleum https://www.eia.gov/state/seds/sep_use/notes/use_print.pdf	2000-2019; *2020 estimated (next release June 2022)*
1b.	Coal Consumed in Electric Power Sector in Hawaii	Trillion BTU per Year	Data: US EIA SED Hawaii (2019) Table CT8. Electric Power Sector Consumption Estimates, Selected Years, 1960-2019, Hawaii https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*
1c.	Coal Consumed Outside the Electric Power Sector in Hawaii	Trillion BTU per Year	Calculation: Total Coal Consumption in Hawaii Minus Coal consumed in Electric Power Sector in Hawaii (Line 1a - Line 1b)	--
1d.	Coal Consumed Outside the Electric Power Sector in Hawaii	Barrel Equivalent	Calculation: Convert Total Coal Consumption in Hawaii (Line 1c) from trillion BTU to barrel equivalent using 1 boe = 5551365.2248856 Btu	--
2a.	Total Natural Gas Consumption in Hawaii	Trillion BTU per Year	Calculation: US EIA SED Hawaii (2019) Table CT2. Primary Energy Consumption Estimates, Selected Years, 1960-2019, Hawaii for Natural Gas https://www.eia.gov/state/seds/seds-data-complete.php?sid=HIexcluding Supplemental Gaseous Fuels	2000-2019; *2020 estimated*
2b.	Natural Gas Consumed in Electric Power Sector in Hawaii	Trillion BTU per Year	Calculation: US EIA SED Hawaii (2019) Table CT8. Electric Power Sector Consumption Estimates, Selected Years, 1960-2019, Hawaii https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*
2c.	Natural Gas Consumed Outside the Electric Power Sector in Hawaii	Trillion BTU per Year	Calculation: Total Natural Gas Consumption in Hawaii Minus Natural Gas Consumed in Electric Power Sector in Hawaii (Line 2a - Line 2b)	--
2d.	Natural Gas Consumed Outside the Electric Power Sector in Hawaii	Barrel Equivalent	Calculation: Convert Natural Gas Consumed Outside the Electric Power Sector in Hawaii (Line 2c) from trillion BTU to barrel equivalent using 1 boe = 5551365.2248856 Btu	--
3a.	Total Petroleum Consumption in Hawaii	Trillion BTU per Year	Data: US EIA SED Hawaii (2019) Table CT2. Primary Energy Consumption Estimates, Selected Years, 1960-2019, Hawaii for Petroleum (Total) https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*

3b.	Petroleum Consumed in Electric Power Sector in Hawaii	Trillion BTU per Year	Data: US EIA SED Hawaii (2019) Table CT8. Electric Power Sector Consumption Estimates, Selected Years, 1960-2019, Hawaii https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*
3c.	Petroleum Consumed Outside the Electric Power Sector in Hawaii	Trillion BTU per Year	Calculation: Total Petroleum Consumption in Hawaii Minus Petroleum Consumed in Electric Power Sector in Hawaii (Line 3a - Line 3b)	--
3d.	Petroleum Consumed Outside the Electric Power Sector in Hawaii	Barrel Equivalent	Calculation: Convert Petroleum Consumed Outside the Electric Power Sector in Hawaii (Line 3c) from trillion BTU to barrel equivalent using 1 boe = 5551365.2248856 Btu	--
4.	Total NRE consumption outside electric power sector	Barrel Equivalent	Calculation: Coal Consumed Outside the Electric Power Sector in Hawaii + Natural Gas Consumed Outside the Electric Power Sector in Hawaii + Petroleum Consumed Outside the Electric Power Sector in Hawaii (Line 1d + Line 2d + Line 3d (in barrel equivalent))	--
5.	Per barrel replacement cost for energy outside electric power sector	2020 USD per Barrel	2000$116 per Barrel Equivalent, based on Makhijani, A. (2007). Carbon-Free and Nuclear Free: A Roadmap for U.S. Energy Policy (p. xx) Takoma Park, Maryland: IEER Press/Muskegon, Michigan: RDR Books. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.169.333&rep=rep1&type=pdf	2007
6.	Replacement cost for NRE consumption outside electric power sector	2020 USD	Calculation: Total NRE consumption outside electric power sector Multiplied by Per barrel replacement cost for energy outside electric power sector (Line 4 * Line 5)	--
7.	Total Electricity Consumed	Trillion BTU per Year	Data: EIA SED Hawaii (2019) Table CT8 Electric Power Sector Consumption Estimates 1960-2019 for Total (trillion BTU) https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*
8.	Electricity from Hydroelectric Energy	Trillion BTU per Year	Data: EIA SED Hawaii (2019) Table CT8 Electric Power Sector Consumption Estimates 1960-2019 for Hydroelectric (trillion BTU) https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*
9.	Electricity from Geothermal	Trillion BTU per Year	Data: EIA SED Hawaii (2019) Table CT8 Electric Power Sector Consumption Estimates 1960-2019 for Geothermal (trillion BTU) https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*
10.	Electricity from Solar	Trillion BTU per Year	Data: EIA SED Hawaii (2019) Table CT8 Electric Power Sector Consumption Estimates 1960-2019 for Solar (trillion BTU) https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*
11.	Electricity from Wind	Trillion BTU per Year	Data: EIA SED Hawaii (2019) Table CT8 Electric Power Sector Consumption Estimates 1960-2019 for Wind (trillion BTU) https://www.eia.gov/state/seds/seds-data-complete.php?sid=HI	2000-2019; *2020 estimated*

12.	Non-Renewable Electricity Consumed	Trillion BTU per Year	Calculation: Total Electricity Consumed-Electricity from Hydroelectric Energy-Electricity from Geothermal-Electricity from Solar-Electricity from Wind (Line 7 - Line 8 - Line 9 -Line 10 - Line 11 (in trillion BTU))	--
13.	Non-Renewable Electricity Consumed	Kilowatt Hours	Calculation: Convert Non-Renewable Electricity Consumed (Line 12) from trillion BTU to kWh by dividing by 3412 * 1x10exp12	--
14.	Per kWh replacement cost of NRE in electricity sector	2020 USD per Kilowatt Hours	Data: $.13/kWh in 2020$;Replacement cost electric sector $/kWh using $.0875 per kwh in 2000 $, based on Makhijani, A. (2007). Carbon-Free and Nuclear Free: A Roadmap for U.S. Energy Policy (p. xx) Takoma Park, Maryland: IEER Press/Muskegon, Michigan: RDR Books. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.169.333&rep=rep1&type=pdf	2007
15.	Replacement Costs for NRE in Electricity Sector (using $.13/kWh in 2020$)	2020 USD	Calculation: Non-Renewable Electricity Consumed Multiplied by Per kWh replacement cost of NRE in electricity sector (Line 13 * Line 14); calculate replacement cost electric sector (2020$) using $.0875 per kWh in 2000$ converted to $.13/kWh in 2020$;	--
16a.	TOTAL REPLACEMENT COSTS for non-renewable energy (NRE)	2020 USD	Calculation: Replacement cost for NRE consumption outside electric power sector Added to Replacement Costs for NRE in Electricity Sector (using $.13/kWh in 2020$) (Line 6+Line 15	--
16b.	TOTAL REPLACEMENT COSTS for non-renewable energy (NRE)	2020 USD, Billions	Calculation: TOTAL REPLACEMENT COSTS for non-renewable energy (NRE) Multiplied by 1,000,000 (Line 16a*1,000,000,000)	--

Groundwater (not included in the GPI calculation due to data gaps)

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Annual GW depletion rate	km3/year	Data: Konikow (2013) Table 2; but values are for Oahu only; Konikow (2013) assumed that the depletion from pumpage accumulates with a linear trend from 1900 to 2003, and that there is then a recovery of 20 percent from 2005 to 2007. (Konikow 2013 page 43)	1960, 1970, 1980, 1990, 2000, 2008
1b.	Annual GW depletion rate converted to acre-ft/year	acre-ft/year	Calculation: Convert using 1 cubic kilometer = 810713.19217801 acre feet	--
2.	Median replenishment cost	2020 USD per acre-ft	Data: T&W cite median replenishment cost $390/acre-ft median replacement cost which inflates to $429.82 in 2020 USD from Rohde (2014) from Stanford Water in the West project https://waterinthewest.stanford.edu/groundwater/recharge/	--
3.	Cost to replace depleted GW	2020 USD	Calculation: Annual GW depletion rate converted to acre-ft/year * Median replenishment cost (Line 1b * Line 2)	--
4.	Cost to replace depleted GW	2020 USD, Billions	Convert to billions 2020$	--

Soil Erosion

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Total surface area in Hawaii	thousands of acres	Data: USDA NRCS 2017 National Resources Inventory (NRI) for Hawaii for every 5 years from 1982-2017 https://www.nrcs.usda.gov/Internet/NRCS_RCA/reports/nri_hi.html	Every 5 years 2000-2020
2.	Non-federal land -- rural -- cropland -- cultivated only	thousands of acres	Data: USDA NRCS 2017 National Resources Inventory (NRI) for Hawaii for every 5 years from 1982-2017 Cropland Use, total cultivated cropland https://www.nrcs.usda.gov/Internet/NRCS_RCA/reports/nri_crop_hi.html	Every 5 years 2000-2020
3.	Soil erosion rate (cropland) held constant over 5 yrs intervals	tons/acre/year	Data: USDA NRCS 2017 National Resources Inventory (NRI) Water (Sheet & Rill) and Wind Erosion on Cropland in Hawaii for years 1982-2017 (every 5 years) https://www.nrcs.usda.gov/Internet/NRCS_RCA/reports/nri_eros_hi.html	Every 5 years 2000-2020
4.	Soil lost from erosion	tons/year	Calculation: Soil erosion rate (cropland) held constant over 5 yrs intervals * Non-federal land -- rural -- cropland -- cultivated only (Line 3*Line 2)	--
5.	Replacement cost for soil	2020 USD/ton	Data: $75.00 per cubic yard converts to $65/ton using 1.15 ton = 1 cubic yard of topsoil (assuming density of 2295lb/cubic yard); T&W used "average of current retail prices for topsoil purchases"; ProMatcher.com gives average $74.57 yd3 (range of $66.28 to $82.85) as of Oct. 2020 https://dirt-delivery.promatcher.com/cost/honolulu-hi-dirt-delivery-costs-prices.aspx Island Top soil $36-$110 yd3	--
6.	Cost of soil erosion (cultivated cropland)	2020 USD	Calculation: Replacement cost for soil * Soil lost from erosion (Line 5*Line 4)	--
7.	Cost of soil erosion (cultivated cropland)	2020 USD, Billions	Calculation: Convert Line 6 to billions 2020$	--

Land Conversion

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Area of developed land	Ha	1) We use CCAP 2005 and 2010/2011 data to calculate the change in land cover. We calculate the average rate of change between 2005-2010 and apply it to all years 2000-2020. 2) We value this change in land cover by the value for that land cover in the ESVD. Specifically, we calculate the NPV of each land cover type. See Appendix Land conversion GIS data for more information	2005, 2010/2011
1b.	Annual change in developed land (2005-2010)	Ha		
1c.	NPV of developed land	NPV 2020 USD/Ha		
2a.	Area of crop/pasture land	Ha		

2b.	Annual change in crop/pasture land (2005-2010)	Ha		
2c.	NPV of crop/pasture land	NPV 2020 USD/Ha		
3a.	Area of forest land	Ha		
3b.	Annual change in forest land (2005-2010)	Ha		
3c.	NPV of forest land	NPV 2020 USD/Ha		
4a.	Area of grass land	Ha		
4b.	Annual change in grass land (2005-2010)	Ha		
4c.	NPV of grass land	NPV 2020 USD/Ha		
5a.	Area of shrub land	Ha		
5b.	Annual change in shrub land (2005-2010)	Ha		
5c.	NPV of shrub land	NPV 2020 USD/Ha		
6a.	Area of palustrine wetland land	Ha		
6b.	Annual change in palustrine land (2005-2010)	Ha		
6c.	NPV of palustrine wetland land	NPV 2020 USD/Ha		
7a.	Area of estuarine wetland land	Ha		
7b.	Annual change in estuarine wetland land (2005-2010)	Ha		
7c.	NPV of estuarine wetland land	NPV 2020 USD/Ha		
8a.	Area of barren land	Ha		
8b.	Annual change in barren land (2005-2010)	Ha		
8c.	NPV of barren land	NPV 2020 USD/Ha		
9a.	Area of ocean	Ha		

9b.	Annual change in ocean (2005-2010)	Ha		
9c.	NPV of ocean	NPV 2020 USD/Ha		
10.	Total value of lost natural capital	2020 USD, Billions		

Social Costs (-SC)

Houselessness

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Hawaii Houseless Count	Persons	Data: CoC Homeless Populations and Subpopulations pdf Reports: https://www.hudexchange.info/programs/coc/coc-homeless-populations-and-subpopulations-reports/?filter_Year=&filter_Scope=State&filter_State=HI&filter_CoC=&program=CoC&group=PopSub	2005-2020; *2000-2004 extrapolated*
2.	Cost per Houseless Individual	2020 USD	Data: $48,885.92 in 2020$; converted from $40,000 in 2008$ from Culhane (2008) as an estimate for use of shelters, public services, health care etc. predominantly by homeless people.	–
3.	Cost of Houselessness in Hawaii	2020 USD	Calculation: Hawaii Houseless Count (Line 1) Multiplied by Cost per Houseless Individual (Line 2)	–
4.	Cost of Houselessness in Hawaii	2020 USD, Billions	Calculation: Cost of Houselessness in Hawaii (Line 4) Divided by 1,000,000,000	–

Underemployment

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Hawaii Unemployment Rate (U3)	%	Data: DBEDT Databook Table 12.06-- EMPLOYMENT STATUS OF THE CIVILIAN LABOR FORCE: ANNUAL AVERAGE, 1990 TO 2020	2000-2020
2.	Hawaii Underemployment Rate (U6)	%	Data: For years 2003 to 2020 use DBEDT Data Table 12.07-- ALTERNATIVE MEASURES OF LABOR UNDERUTILIZATION FOR HAWAII AND THE UNITED STATES AVERAGE: 2003 TO 2019 https://files.hawaii.gov/dbedt/economic/databook/db2019/section12.pdf; see also BLS Alternative Measures of Labor Underutilization for States, 20xx Annual Averages https://www.bls.gov/lau/stalt20q4.htm; for years 2000 to 2002, use Line 3*Line 1 to estimate U6	2003-2020; 2000-2002 see Line 3
3.	Average ratio of U6 to U3 for years 2003 to 2020	%	Calculation: Hawaii Underemployment Rate (U6)/Hawaii Unemployment Rate (U3) (Line 2/Line 1) (ratio used to calculate a proxy for years 2000 to 2002 in which BLS U6 data	--

			are not available)	
4.	Hawaii labor force	Persons	Data: BLS local area unemployment statistics (LAUS) https://www.bls.gov/lau/	2000-2020
5.	Hawaii underemployed persons	Persons	Calculation: Hawaii labor force*Hawaii underemployment rate (Line 4*Line 2)/100 to estimate number of underemployed workers	--
6.	Annual unprovided hours per underemployed person	Hours per Person	Calculation: following traditional GPI studies, uses baseline of 803 hours in 1989 and assumes increase of 0.59% of continued annual growth in unprovided hours each year onwards (as per Leete-Guy and Schorr , 1992)	–
7.	Personal income per capita for Hawaii	Current USD	Data: Personal income per capita for Hawaii from BEA; SAINC1 Personal Income Summary: Personal Income, Population, Per Capita Personal Income	2000-2020
8.	Hawaii average hourly wage rate	Current USD	Calculation: Personal income per capita for Hawaii/52/40 (Line 7)/52/40 to convert to hourly wages (or assuming 2080 hours worked per year)	--
9.	Hawaii average hourly wage rate	2020 USD	Calculation: Line 8/CPI-U to convert to 2020$	
10.	Hawaii Costs of Underemployment	2020 USD, Billions	Calculation: Hawaii underemployed persons*Annual unprovided hours per underemployed person*Hawaii average hourly wage rate/1,000,000,000 in 2020$ (Line 5*Line 6*Line 9/10^9 in 2020$)	--

Crime

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Number of Murders in Hawaii		Data: Crime in Hawaii, Uniform Crime Reports Trend Series (1975-2019), by county for 2020; http://ag.hawaii.gov/cpja/rs/cih/	2000-2020
1b.	Cost per Murder	2020 USD	Data: Following other GPI studies using $2.94M in 1993$ converted to $5.3M in 2020$; see Annual Costs of Crime, U.S. DOJ Victims Cost & Consequences https://www.ojp.gov/pdffiles/victcost.pdf	–
1c.	Cost of Murders in Hawaii	2020 USD	Calculation: Number of Murders in Hawaii Multiplied by Cost per Murder (Line 1a*Line 1b)	--

2a.	Number of Rapes in Hawaii		Data: Crime in Hawaii, Uniform Crime Reports Trend Series (1975-2019), by county for 2020; http://ag.hawaii.gov/cpja/rs/cih/	2000-2020
2b.	Cost per Rape	2020 USD	Data: Following other GPI studies using $87,000 in 1993$ converted to $157,387.64 in 2020$; see Annual Costs of Crime, U.S. DOJ Victims Cost & Consequences https://www.ojp.gov/pdffiles/victcost.pdf; Table 2, Page 9	–
2c.	Cost of Rapes in Hawaii	2020 USD	Calculation: Number of Rapes in Hawaii Multiplied by Cost per Rape (Line 2a*Line 2b)	--
3a.	Number of Robberies in Hawaii		Data: Crime in Hawaii, Uniform Crime Reports Trend Series (1975-2019), by county for 2020; http://ag.hawaii.gov/cpja/rs/cih/	2000-2020
3b.	Cost per Robbery	2020 USD	Data: Following other GPI studies, using $8,000 in 1993$ converted to $14,472.43 in 2020$; see Annual Costs of Crime, U.S. DOJ Victims Cost & Consequences https://www.ojp.gov/pdffiles/victcost.pdf; Table 2, Page 9	–
3c.	Cost of Robberies in Hawaii	2020 USD	Calculation: Number of Robberies in Hawaii Multiplied by Cost per Robbery (Line 3a*Line 3b)	--
4a.	Number of Aggravated Assaults in Hawaii		Data: Crime in Hawaii, Uniform Crime Reports Trend Series (1975-2019), by county for 2020; http://ag.hawaii.gov/cpja/rs/cih/	2000-2020
4b.	Cost per Aggravated Assault	2020 USD	Data: Following other GPI studies using $9,400 in 1993$ converted to $17,005.10 in 2020$ Annual Costs of Crime, U.S. DOJ Victims Cost & Consequences https://www.ojp.gov/pdffiles/victcost.pdf; Table 2, Page 9	–
4c.	Cost of Aggravated Assaults in Hawaii	2020 USD	Calculation: Number of Aggravated Assaults in Hawaii Multiplied by Cost per Aggravated Assault (Line 4a*Line 4b)	--
5a.	Number of Break-and-Enters in Hawaii		Data: Crime in Hawaii, Uniform Crime Reports Trend Series (1975-2019), by county for 2020; http://ag.hawaii.gov/cpja/rs/cih/	2000-2020
5b.	Cost per Break-and-Enter	2020 USD	Data: Following other GPI studies using $1,400 in 1993$ converted to $2,532.67 in 2020$; see Annual Costs of Crime, U.S. DOJ Victims Cost & Consequences https://www.ojp.gov/pdffiles/victcost.pdf; Table 2, Page 9	–
5c.	Cost of Break-and-Enters in Hawaii	2020 USD	Calculation: Number of Break-and-Enters in Hawaii Multiplied by Cost per Break-and-Enter (Line 5a*Line 5b)	--
6a.	Number of Larceny Thefts in		Data: Crime in Hawaii, Uniform Crime Reports Trend Series (1975-2019), by county for	2000-2020

	Hawaii		2020; http://ag.hawaii.gov/cpja/rs/cih/	
6b.	Cost per Larceny Theft	2020 USD	Data: Following other GPI studies using $370 in 1993$ converted to $669.35 in 2020$; see Annual Costs of Crime, U.S. DOJ Victims Cost & Consequences https://www.ojp.gov/pdffiles/victcost.pdf; Table 2, Page 9	–
6c.	Cost of Larceny Thefts in Hawaii	2020 USD	Calculation: Number of Larceny Thefts in Hawaii Multiplied by Cost per Larceny Theft (Line 6a*Line 6b)	--
7a.	Number of Motor Vehicle Thefts in Hawaii		Data: Crime in Hawaii, Uniform Crime Reports Trend Series (1975-2019), by county for 2020; http://ag.hawaii.gov/cpja/rs/cih/	2000-2020
7b.	Cost per Motor Vehicle Theft	2020 USD	Data: Following other GPI studies using $3,700 in 1993$ converted to $6,693.50 in 2020$; see Annual Costs of Crime, U.S. DOJ Victims Cost & Consequences https://www.ojp.gov/pdffiles/victcost.pdf; Table 2, Page 9	–
7c.	Cost of Motor Vehicle Thefts in Hawaii	2020 USD	Calculation: Number of Motor Vehicle Thefts in Hawaii Multiplied by Cost per Motor Vehicle Theft (Line 7a*Line 7b)	--
8a.	Total Victims Costs	2020 USD	Calculation: (Cost of Murders in Hawaii + Cost of Rapes in Hawaii + Cost of Robberies in Hawaii + Cost of Aggravated Assaults in Hawaii + Cost of Break-and-Enters in Hawaii + Cost of Larceny Thefts in Hawaii + Cost of Motor Vehicle Thefts in Hawaii) (Line 1c + 2c + 3c + 4c + 5c + 6c + 7c)	--
8b.	Total Victims Costs	2020 USD, Billions	Calculation: Total Victims Costs/CPI-U (Line 8a/1,000,000,000)	--

Vehicle Crashes

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1a.	Fatalities from Motor Vehicle Crashes	Persons	Data: DBEDT Data Book 2020 Table 18.20-- Major Traffic Accidents, Traffic Injuries, and Traffic Deaths 2000 to 2019; also see National Highways Transportation Safety Administration (NHTSA) Fatality Analysis Reporting Systems (FARS) https://www-fars.nhtsa.dot.gov/States/StatesCrashesAndAllVictims.aspx;	2000-2019; *2020 extrapolated*
1b.	Cost per death	2020 USD	Data: Follows previous GPI studies but uses more recent estimates of motor vehicle crash fatalities of $1,398,916 per fatality in 2010$ converted to $1,665,442.59 in 2020$; from Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2015, May).The economic and societal impact of motor vehicle crashes, 2010. (Revised) (Report No. DOT HS 812 013).	–

			Washington, DC: National Highway Traffic Safety Administration. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013	
1c.	Total cost of deaths from motor vehicle crashes		Calculation: Fatalities from Motor Vehicle Crashes in Hawaii Multiplied by Cost per Fatality (Line 1a*Line 1b)	--
2a.	Number of Injuries from motor vehicle crashes	Persons	Data: DBEDT Data Book 2020 Table 18.20-- Major Traffic Accidents, Traffic Injuries, and Traffic Deaths 2000 to 2019	2000-2019; *2020 extrapolated*
2b.	Cost per Injury	2020 USD	Data: Follows previous GPI studies but with updated estimates for motor vehicle crash injuries using an average cost across Maximum Abbreviated Injury Scale (MAIS = $275,669.67 per injury in 2010$ converted to $328,191.66 in 2020$; from Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2015, May).The economic and societal impact of motor vehicle crashes, 2010. (Revised) (Report No. DOT HS 812 013). Washington, DC: National Highway Traffic Safety Administration. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013	–
2c.	Total Cost of Injuries from Motor Vehicle Crashes		Calculation: Number of Injuries from motor vehicle crashes Multiplied by Cost per Injury (Line 2a*Line 2b)	--
3a.	Cost of Motor Vehicle Crashes	2020 USD	Calculation: Total cost of deaths from motor vehicle crashes Added to Total Cost of Injuries from Motor Vehicle Crashes (Line 1c+Line 2c)	--
3b.	Cost of Motor Vehicle Crashes	2020 USD, Billions	Calculation: Cost of Motor Vehicle Crashes Divided by 1,000,000,000 to convert to 2020$ (Line 3a/1,000,000,000)	--

Commuting

Line Item	Variable	Units	Value or Cost/Calculation Methodology/Data Source	Years Available
1.	Fares for The Bus	Current USD	Data: DBEDT Data Book 2020 Table 18.26-- BUS FARE CHRONOLOGY, FOR OAHU;	2000-2020
2.	Percent Hawaii Workers Taking Public Transit from ACS	%	Data: For years 2010-2019 use ACS Table S0801 for 2010-2019; for For years 2000-2004, use 2000 Census and extrapolate: US Census Bureau publication C2KPROF/00-HI Hawaii 2000: Census 2000 Profile Table DP-3. For 2005-2009 For years 2005-2009, based on previous ACS data tables (and values recorded in our prior GPI spreadsheet from 2014) but those data were not yet migrated from FactFinder to census.gov; For 2020, data pending release (expected March 2022), use 2020 ACS 1-Year Experimental Estimates (under Economic) Tables XK200801 Means of Travel to Work (by state) and XK200802 Travel Time	2000, *2001-2004 extrapolated*; 2005-2009 previous GPI records; 2010-2019; *2020 experimental tables*

			to Work (by state)	
3.	Hawaii Workers ages 16+ from ACS for Hawaii	Persons	Data: From ACS Table S0801; https://data.census.gov/cedsci/table?q=S08&g=0400000US15&d=ACS%201-Year%20Estimates%20Subject%20Tables&tid=ACSST1Y2010.S0801&hidePreview=true	2000-2019; *2020 experimental tables*
4.	Number of Workers Taking Public Transit	Persons	Calculation: Hawaii Workforce * Percent of Workers Taking Public Transit (Line 3 * (Line 2/100))	--
5.	Total Direct Public Transit Costs	Current USD	Calculation: # in workforce taking bus x 250 work days per year x 2 trips per day x one way fare (Line 4 * 2 * 250 * Line 1)	--
6.	Total Direct Public Transit Costs	2020 USD	Calculation: Total Direct Public Transit Costs / CPI-U (to adjust to base year) (Line 5 / CPI-U)	--
7.	Percent Workers Driving Alone	%	Data: From ACS Table S0801 for 2005-2012;percent of workers 16 years and older drove alone vs. carpooled; https://data.census.gov/cedsci/table?q=S08&g=0400000US15&d=ACS%201-Year%20Estimates%20Subject%20Tables&tid=ACSST1Y2019.S0801&hidePreview=true	2000-2019; *2020 experimental tables*
8.	Percent Workers Carpooling	%	Data: From ACS Table S0801 for 2005-2012;percent of workers 16 years and older drove alone vs. carpooled; https://data.census.gov/cedsci/table?q=S08&g=0400000US15&d=ACS%201-Year%20Estimates%20Subject%20Tables&tid=ACSST1Y2019.S0801&hidePreview=true	2000-2019; *2020 experimental tables*
9.	Number of Cars Commuting	Vehicles	Calculation: Number of workers driving alone plus 50% of workers who carpool; (Line 7/ 100 * Line 3)+((Line 8 / 100 * Line 3) * 0.5)	--
10.	Annual Vehicle Average Miles Traveled	VMT per Vehicle	Data: DBEDT Data Book 2020; Table 18.17-- MOTOR VEHICLE FUEL CONSUMPTION AND VEHICLE MILES, 1992 TO 2020;	2000-2020
11.	VMT to and from work	30% of VMT	Calculation: Assume 30% of annual VMT to/from work based on figures from Table 24. Commute Trips and VMT and Total VMT by Year 1969, 1977, 1983, 1990 and 1995 NPTS, and 2001 and 2009 NHTS.	--
12.	GSA POV Rates per Mile	Current USD	Data: US GSA POV rates https://www.gsa.gov/travel/plan-book/transportation-airfare-pov-etc/privately-owned-vehicle-mileage-rates/pov-mileage-rates-archived	2000-2020
13.	Total Direct Driving Costs	Current USD	Calculation: (Average Annual VMT x 30% x GSA rate per mile); (Line 9 * Line 11 * Line 12)	--
14.	Total Direct Driving Costs	2020 USD	Calculation: Total Direct Driving Costs / CPI-U (to adjust to base year); Line 14 / CPI-U	--
15.	Hawaii Mean Travel Time to Work, One Way	Minutes	Data: Census; COMMUTING CHARACTERISTICS BY SEX; https://data.census.gov/cedsci/table?q=S08&g=0400000US15&d=ACS%201-Year%20Estimates%20Subject%20Tables&tid=ACSST1Y2010.S0801&hidePreview=true	2000-2019; *2020 extrapolated*

16.	Total Annual Hours Spent Commuting	Hours per Year	Calculation: (Hawaii Mean Travel Time to Work * 2 trips * 250 workdays)/60 minutes; (Line 15 * 2 * 250)/60	--
17.	Number of workers working from home (not commuting)	Persons	For year 2000 see Hawaii Census 2000 Profile (C2KPROF/00-HI issued Aug 2002); Years 2001 to 2009 are interpolated; Years 2010-2019 from ACS Table S0801 for 2010-2019; for 2020 use Census ACS 2020 experimental data table XK200801	2000; *2001-2009 extrapolate;* 2010-2019; *2020 experimental data*
18.	Average Annual Wage	Current USD	Data: DBEDT Data Book 2020 Table 12.29, "Average Annual Wage in Current & Constant Dollars: 1969-2019"	2000-2019; *2020 extrapolated*
19.	Average Annual Hourly Wage Adjusted for Non-Nuisance Factor	Current USD	Calculation: (Average Annual Wage/2000)*0.72; (Line 18/2000)*0.72; divided by 2000 to convert to hourly wage rate (assuming 8 hours per day and 250 work days per year) x 72% non-nuisance factor	--
20.	Total Indirect Cost of Commuting	Current USD	Calculation: Total Annual Hours Spent Commuting * Average Annual Hourly Wage (Adjusted) * (# Workers 16+ years - # workers working at home); or Line 16 * Line 19 * (Line 3 - Line 17)	--
21.	Total Indirect Cost of Lost Time	2020 USD	Calculation: Total Indirect Cost of Time / CPI-U (to adjust to base year); Line 20/CPI-U	--
22.	Total Direct plus Indirect Costs of Commuting	2020 USD	Calculation: (Total Direct Public Transit Costs + Total Direct Driving Costs + Total Indirect Cost of Lost Time); (Line 6 + Line 14+ Line 21)	--
23.	Total Direct plus Indirect Costs of Commuting	2020 USD, Billions	Calculation: (Total Direct Public Transit Costs + Total Direct Driving Costs + Total Indirect Cost of Lost Time)/1000000000; (Line 22)/1000000000	--